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Supreme Court, U.S.
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No. 99-1996

In The

Supreme Court of the United States

J.E.M. AG SUPPLY, INC. (doing business as Farm Advantage, Inc.), FARM ADVANTAGE, INC., LARRY BENZ, MERLE PRUETT (doing business as Siouxland Seeds, Inc.), KEVIN WOLFSWINKEL, TIM KAMSTRA, and TOM EISCHEN SEED & CHEMICALS,

Petitioners,

v.

PIONEER HI-BRED INTERNATIONAL, INC.,

Respondent.

On Writ Of Certiorari To The United States Court Of Appeals For The Federal Circuit

JOINT APPENDIX
VOLUME II, PAGES 27 TO 69

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	5,567,861	10/22/96	Inbred Corn Line PHN46
3489	5,557,035	09/17/96	Hybrid Corn Plant & Seed (3489)
	5,633,427	05/27/97	Inbred Corn Line PHHB
	5,444,178	08/22/95	Inbred Corn Line PHHB4
	5,347,081	09/13/94	Inbred Corn Line PHK56
3559	5,453,564	09/26/95	Inbred Corn Line PHTE4
	5,495,069	02/27/96	Inbred Corn Line PHTE4
	5,569,822	10/29/96	Inbred Corn Line PHTE4
	5,534,661	08/09/96	Inbred Maize Line PHKW3
3730	5,689,036	11/18/97	Hybrid Maize Plant and Seed (3730)
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	5,444,178	08/22/95	Inbred Corn Line PHHB4
	5,347,081	09/13/94	Inbred Corn Line PHK56
35N05	5,502,272	03/26/96	Hybrid Corn Plant and Seed (3563)
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	5,347,081	09/13/94	Inbred Corn Line PHK56
34K77	5,534,661	07/09/96	Inbred Maize Line PHKW3
35R57	5,689,034	11/18/97	Inbred Maize Line PH24E
3563	5,502,272	03/26/96	Hybrid Corn Plant and Seed (3563)
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	5,347,081	09/13/94	Inbred Corn Line PHK56
3751	5,082,992	01/21/92	Inbred Corn Line PHP02

U.S. Patent No. 5,491,295 (hybrid corn line)

US005491295A

United States Patent [19]

Niebur et al.

[11] Patent Number: 5,491,295

[45] Date of Patent: Feb. 13, 1996

[54] **HYBRID CORN PLANT AND SEED**

[75] Inventors: William S. Niebur, Victor, France; Raymond D. Riley, Humboldt County; Stephen W. Noble, Polk County, both of Iowa

[73] Assignee: Pioneer Hi-Bred International, Inc., Des Moines, Iowa

[21] Appl. No.: 323,273

[22] Filed: Nov. 22, 1994

Related U.S. Application Data

[63] Continuation of Ser. No. 962,443, Oct. 16, 1992, abandoned, which is a continuation of Ser. No. 649,786, Feb. 1, 1991, abandoned.

[51] Int. Cl.[6] A01H 5/00; A01H 4/00; C12M 5/04

[52] U.S. Cl. 800/200; 800/250; 800/DIG. 56; 47/58; 435/240.4; 435/240.49; 435/240.5

[58] Field of Search 800/200, 205, 800/DIG. 56; 47/58.03, 58.05; 435/240.4, 240.49, 240.5

[56] **References Cited**

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Primary Examiner—Gary Benzion

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[57] **ABSTRACT**

According to the invention, there is provided a hybrid corn plant, designated as 3394, produced by crossing two Pioneer Hi-Bred International, Inc. proprietary inbred corn lines. This invention thus relates to the hybrid seed 3394, the hybrid plant produced from the seed, and variants, mutants, and trivial modifications of hybrid 3394. This hybrid corn plant is characterized by superior yield for maturity, excellent seedling vigor, very good roots and stalks, and exceptional stay green. It is widely adapted, but performs best in the Central and Eastern Corn Belt.

6 Claims, No Drawings

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HYBRID CORN PLANT AND SEED

This application is a continuation of prior application Ser. No. 07/962,443, filed Oct. 16, 1992, now abandoned, which was a continuation of prior application Ser. No. 07/649,786, field Feb. 1, 1991, now abandoned.

FIELD OF THE INVENTION

This invention is in the field of plant breeding, specifically hybrid corn breeding.

BACKGROUND OF THE INVENTION

The goal of plant breeding is to combine in a single variety/hybrid various desirable traits of the parental lines. For field crops, these traits may include resistance to diseases and insects, tolerance to heat and drought, reducing the time to crop maturity, greater yield, and better agronomic quality. With mechanical harvesting of many crops, uniformity of plant characteristics such as germination and stand establishment, growth rate, maturity, and fruit size, is important.

Field crops are bred through techniques that take advantage of the plant's method of pollination. A plant is self-pollinating if pollen from one flower is transferred to the same or another flower of the same plant. A plant is cross-pollinated if the pollen comes from a flower on a different plant.

Plants that have been self-pollinated and selected for type for many generations become homozygous at almost all gene loci and produce a uniform population of true breeding progeny. A cross between two homozygous lines produces a uniform population of hybrid plants that may be heterozygous for many gene loci. A cross of two plants each heterozygous at a number of gene loci will produce a population of hybrid plants that differ genetically and will not be uniform.

Corn plants (Zea mays L.) can be bred by both self-pollination and cross-pollination techniques. Corn has male flowers, located on the tassel, and female flowers, located on the ear, on the same plant. Natural pollination occurs in corn when wind blows pollen from the tassels to the silks that protrude from the tops of the incipient ears.

The development of corn hybrids requires the development of homozygous inbred lines, the crossing of these lines, and the evaluation of the crosses. Pedigree breeding and recurrent selection breeding methods are used to develop inbred lines from populations. Breeding programs combine desirable traits from two or more inbred lines or various broad-based sources into breeding pools from which new inbred lines are developed by selfing and selection of desired phenotypes. The new inbreds are crossed with other inbred lines and the hybrids from these crosses are evaluated to determine which have commercial potential.

Pedigree breeding starts with the crossing of two genotypes, each of which may have one or more desirable characteristics that is lacking in the other or which complement the other. If the two original parents do not provide all of the desired characteristics, other sources can be included in the breeding population. In the pedigree method, superior plants are selfed and selected in successive generations. In the succeeding generations the heterozygous condition gives way to homogeneous lines as a result of self-pollination and selection. Typically in the pedigree method of breeding five

or more generations of selfing and selection is practiced. $F_1 \rightarrow F_2$; $F_2 \rightarrow F_3$; $F_3 \rightarrow F_4$; $F_4 \rightarrow F_5$, etc.

A hybrid corn variety is the cross of two inbred lines, each of which may have one or more desirable characteristics lacked by the other or which complement the other. The hybrid progeny of the first generation is designated F_1. In the development of hybrids only the F_1 hybrid plants are sought. The F_1 hybrid is more vigorous than its inbred parents. This hybrid vigor, or heterosis, can be manifested in many ways, including increased vegetative growth and increased yield.

The development of a hybrid corn variety involves three steps: (1) the selection of superior plants from various germplasm pools; (2) the selfing of the superior plants for several generations to produce a series of inbred lines, which although different from each other, each breed true and are highly uniform; and (3) crossing the selected inbred lines with unrelated inbred lines to produce the hybrid progeny (F_1). During the inbreeding process the vigor of the lines decreases. Vigor is restored when two unrelated inbred lines are crossed to produce the hybrid progeny (F_1). An important consequence of the homozygosity and homogeniety of the inbred lines is that the hybrid between any two inbreds will always be the same. Once the inbreds that give the best hybrid have been identified, the hybrid seed can be reproduced indefinitely as long as the homogeneity of the inbred parents is maintained.

A single cross hybrid is produced when two inbred lines are crossed to produce the F_1 progeny. A double cross hybrid, is produced from four inbred lines crossed in pairs (A×B and C× D) and then the two F_1 hybrids are crossed again (A×B)×(C× D). Much of the hybrid vigor exhibited by F_1 hybrids is lost in the next generation (F_2). Consequently, seed from hybrid varieties is not used for planting stock.

Hybrid corn seed can be produced by manual detasseling. Alternate strips of two inbred varieties of corn are planted in a field, and the pollen-bearing tassels are removed from one of the inbreds (female). Providing that there is sufficient isolation from sources of foreign corn pollen, the ears of the detasseled inbred will be fertilized only from pollen from the other inbred (male), and the resulting seed is therefore hybrid and will form hybrid plants.

The laborious detasseling process can be avoided by using cytoplasmic male-sterile (CMS) inbreds. Plants of a CMS inbred are fertilized with pollen from another inbred that is not male-sterile. Pollen from the second inbred can contribute genes that make the hybrid plants male-fertile. Usually seed from detasseled normal corn and CMS produced seed of the same hybrid is blended to insure that adequate pollen loads are available for fertilization when the hybrid plants are grown.

Corn is an important and valuable field crop. Thus, a continuing goal of plant breeding is to develop stable high yielding corn hybrids that are agronomically sound. The reasons for this goal are obvious: to maximize the amount of grain produced on the land used and to supply food for both animals and humans.

SUMMARY OF THE INVENTION

According to the invention, there is provided a hybrid corn plant, designated as 3394, produced by crossing two Pioneer Hi-Bred International, Inc. proprietary inbred corn lines. This invention thus relates to the hybrid seed 3394, the hybrid plant produced from the seed, and variants, mutants, and trivial modifications of hybrid 3394. This hybrid corn plant is characterized by superior yield for maturity, excel-

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lent seedling vigor, very good roots and stalks, and exceptional stay green. It is widely adapted, but performs best in the Central and Eastern Corn Belt.

DEFINITIONS

In the description and examples that follow, a number of terms are used herein. In order to provide a clear and consistent understanding of the specification and claims, including the scope to be given such terms, the following definitions are provided:

ADVANTAGE=It is the advantage the hybrid to be patented has compared to another hybrid for yield (bushels per acre), moisture (drier is an advantage), income, population, stand (plants not stalk lodging is an advantage), roots (plants not root lodging is an advantage), and test weight, respectively, in strip tests.

BAR PLT=BARREN PLANTS. This is the percent of plants per plot that were not barren (lack ears). 5 B/STK=BRITTLE STALKS RATING. This is a 1-9 rating where a 1, 5, and 9 represent serious, average, and little or no potential for brittle stalk breakage.

BRT STK=BRITTLE STALKS. This is a measure of the stalk breakage near the time of pollination, and is an indication of whether a hybrid would snap or break near the time of flowering under severe winds. Data are presented as percentage of plants that did not snap.

BU ACR=YIELD (BUSHELS/ACRE). Actual yield of the grain at harvest adjusted to 15.5% moisture. ABS is in absolute terms and % MN is percent of the mean for the experiments in which the hybrid was grown.

D/D=DRYDOWN. This represents the relative rate at which a hybrid will reach acceptable harvest moisture compared to other hybrids on a 1-9 rating scale. A high score indicates a hybrid that dries relatively fast while a low score indicates a hybrid that dries slowly.

D/E=DROPPED EARS RATING. This is a 1-9 rating where a 1, 5, and 9 represent serious, average, and little or no ear droppage potential, respectively.

DRP EAR=DROPPED EARS. This is a measure of the number of dropped ears per plot and represents the percentage of plants that did not drop ears prior to harvest.

D/T=DROUGHT TOLERANCE. This represents a 1-9 rating for drought tolerance, and is based on data obtained under stress conditions. A high score indicates good drought tolerance and a low score indicates poor drought tolerance.

E/HT=EAR HEIGHT RATING. This is a 1-9 rating with a 1, 5, and 9 representing a very low, average, and very high ear placement, respectively.

EAR HT=EAR HEIGHT. The ear height is a measure from the ground to the top developed ear node attachment and is measured in inches.

EST CNT=EARLY STAND COUNT. This is a measure of the stand establishment in the spring and represents the number of plants that emerge on a per plot basis for the hybrid.

GDU BL=GDU TO BLACKLAYER. This is the number of growing degree units required for the hybrid to reach blacklayer from the time that it was planted. Growing degree units are calculated by the Barger Method, where the heat units for a 24-hour period are:

$$GDU = \frac{(\text{Max.} + \text{Min.})}{2} - 50$$

The highest maximum used is 86° F. and the lowest minimum used is 50° F. For each inbred or hybrid it takes a certain number of GDUs to reach various stages of plant development.

GDU SHD=GDU TO SHED. The number of growing degree units (GDUs) or heat units required for a hybrid to have approximately 50 percent of the plants shedding pollen and is measured from the time of planting.

GDU SLK=GDU TO SILK. The number of growing degree units required for a hybrid to have approximately 50 percent of the plants with silk emergence from time of planting.

GRN APP=G/A=GRAIN APPEARANCE. This is a 1 to 9 rating for the general quality of the shelled grain as it is harvested based on such factors as the color of the harvested grain, any mold on the grain, and any cracked grain. High scores indicate good grain quality and low scores indicate poor grain quality.

H/POP=YIELD AT HIGH DENSITY. Yield ability at relatively high plant densities on a 1-9 relative rating system with a higher number indicating the hybrid responds well to high plant densities for yield relative to other hybrids. A 1, 5, and 9 would represent very poor, average, and very good yield response, respectively, to increased plant density.

INCOME/ACRE: Relative income per acre assuming drying costs of two cents per point above 15.5 percent harvest moisture and market price of $2.25 per bushel.

L/POP=YIELD AT LOW DENSITY. Yield ability at relatively low plant densities on a 1-9 relative system with a higher number indicating the hybrid responds well to low plant densities for yield relative to other hybrids. -A 1, 5, and 9 would represent very poor, average, and very good yield response, respectively, to low plant density.

MST=MOIST=HARVEST MOISTURE. Harvest moisture is the actual percentage moisture of the grain at harvest.

MST RM=MOISTURE RM. This represents the Minnesota Relative Maturity Rating (MN RM) for the hybrid and is based on the harvest moisture of the grain relative to a standard set of checks of previously determined MN RM rating. Linear regression analysis is used to compute this rating.

P/HT=PLANT HEIGHT RATING. This is a 1-9 rating with a 1, 5, and 9 representing a very short, average, and very tall hybrid, respectively.

PLT HT=PLANT HEIGHT. This is a measure of the height of the plant from the ground to the tip of the tassel in inches.

PoP K/ACRE: Plants per 0.001 acre.

PERCENT WINS: For yield, moisture, income, populations, stand, roots, and test weight, it would be the percentage of comparisons that the hybrid to be patented yielded more, had lower harvest moisture percentage, had greater income per acre, had better stalks, had better roots, and had higher test weight, respectively, in strip tests.

R/L=ROOT LODGING RATING. A 1-9 rating where a higher score indicates less root lodging potential (1 is very poor, 5 is intermediate, and 9 is very good, respectively, for resistance to root lodging).

ROOT (%): Percentage of plants that did not root lodge (lean greater than 30 degrees from vertical) taken on strip test plots.

RT LDG=ROOT LODGING. Root lodging is the percentage of plants that do not root lodge; plants that lean from the vertical axis at an approximately 30° angle or greater would be counted as root lodged.

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S/L=STALK LODGING RATING. This is a 1–9 rating where a higher score indicates less stalk lodging potential (1 is very poor, 5 is intermediate, and 9 is very good, respectively, for resistance to stalk lodging).

SDG VGR=S/VIG=SEEDLING VIGOR. This is the visual rating (1 to 9) of the amount of vegetative growth after emergence at the seedling stage (approximately five leaves). A higher score indicates better vigor and a low score indicates poorer vigor.

STA GRN=STGR=STAY GREEN. Stay green is the measure of plant health near the time of black layer formation (physiological maturity) using a 1–9 visual rating. A high score indicates better late-season plant health and a low score indicates poor plant health.

STAND (%): Percentage of plants that did not break (lodge) below the ear taken on strip test plots.

STK LDG=STALK LODGING. This is the percentage of plants that did not stalk lodge (stalk breakage) as measured by either natural lodging or pushing the stalks and determining the percentage of plants that break below the ear.

T/WT=TEST WEIGHT RATING. This is a 1–9 relative rating with a 1, 5, and 9 indicating very low, average, and very high test weight, respectively.

TST WTA=TEST WEIGHT. The measure of the weight of the grain in pounds for a given volume (bushel) adjusted for percent moisture.

YLD=YIELD FOR MATURITY. This represents a 1–9 rating for a hybrid's yield potential. 1, 5, and 9 would represent very poor, average, and very high yield potential, respectively, relative to other hybrids of a similar maturity.

DETAILED DESCRIPTION OF THE INVENTION

Pioneer Brand Hybrid 3394 is a single cross, yellow endosperm, dent corn hybrid with superior yield in its maturity. It has stable yield across environments, has above average grain appearance with average test weight, and has exceptional stay green. 3394 has excellent seedling vigor and very good drought tolerance. The inventor has observed that the leaf angle is semi upright and the leaf is short and wide, which is a unique characteristic of this hybrid. The hybrid has the potential to form an abscision layer and drop ears free from the husk.

This hybrid has the following characteristics based on the descriptive data collected primarily at Johnston, Iowa.

VARIETY DESCRIPTION INFORMATION
HYBRID = PIONEER BRAND 3394
Type: Dent Region Best Adapted: Central Corn Belt

A. Maturity:

Minnesota Relative Maturity Rating (harvest moisture):	111
GDU's to Physiological maturity (black layer):	2760
GDU's to 50% Silk:	1442

$$GDU's = \frac{[Max.\ Temp.\ (< 86^\circ F.) + Min.\ Temp\ (> 50^\circ F.)]^*}{2} - 50$$

B. Plant Characteristics:

Plant height (to tassel tip):	296 cm
Length of top ear internode:	16 cm
Number of ears per stalk:	Single

-continued

VARIETY DESCRIPTION INFORMATION
HYBRID = PIONEER BRAND 3394
Type: Dent Region Best Adapted: Central Corn Belt

Ear height (to base of top ear):	101 cm
Number of tillers:	None
Cytoplasm type:	Normal
C. Leaf:	
Color:	Dark Green (B14)
Angle from Stalk:	<30 degrees
Marginal Waves:	Few (WP9)
Number of Leaves (mature plants):	20
Sheath Pubescence:	Light (W22)
Longitudinal Creases:	Many (PA11)
Length (Ear node leaf):	94 cm
Width (widest point, ear node leaf):	10 cm
D. Tassel:	
Number lateral branches:	6
Branch Angle from central spike:	>45 degrees
Pollen Shed:	Heavy (KY21)
Peduncle Length (top leaf to basal branches):	22 cm
Anther Color:	Purple
Glume Color:	Green
E. Ear (Husked Ear Data Except When Stated Otherwise):	
Length:	20 cm
Weight:	238 gm
Mid-point Diameter:	47 mm
Silk Color:	Pink
Husk Extension (Harvest stage):	Short (Ears Exposed)
Husk Leaf:	Short (< 8 cm)
Taper of Ear:	Slight
Position of Shank (dry husks):	Upright
Kernel Rows:	Slightly Curved, Distinct Number = 16
Husk Color (fresh):	Light Green
Husk Color (dry):	Buff
Shank Length:	11 cm
Shank (No. of internodes):	7
F. Kernel (Dried):	
Size (from ear mid-point)	
Length:	13 mm
Width:	8 mm
Thick:	4 mm
Shape Grade (% rounds):	<20%
Pericarp Color:	Colorless
Aleurone Color:	Homozygous Yellow
Endosperm Color:	Yellow
Endosperm Type:	Normal Starch
Gm Wt/100 Seeds (unsized):	34 gm
G. Cob:	
Diameter at mid-point:	26 mm
Strength:	Strong
Color:	Red
H. Diseases:	
Corn Lethal Necrosis (MCMV = Maize Chlorotic Mottle Virus and MDMV = Maize Dwarf Mosaic Virus):	Resistant
Common Smut (*U. maydis*):	Highly Resistant
Anthracnose Stalk Rot (*C. graminicola*):	Intermediate
S. Leaf Blight (*B. maydis*):	Intermediate
N. Leaf Blight (*E. turcicum*):	Intermediate
Gray Leaf Spot (*C. zeae*):	Susceptible
Goss's Wilt (*C. nebraskense*):	Highly Resistant
Head Smut (*S. reiliana*):	Highly Resistant
Fusarium Ear Mold (*F. moniliforme*):	Resistant
I. Insects:	
European Corn Borer-1 Leaf Damage (Pre-flowering):	Susceptible
European Corn Borer-2	Intermediate

-continued

VARIETY DESCRIPTION INFORMATION
HYBRID = PIONEER BRAND 3394
Type: Dent Region Best Adapted: Central Corn Belt

(Post-flowering):	
The above descriptions are based on a scale of 1–9, 1 being highly susceptible, 9 being highly resistant.	
S (Susceptible):	Would generally represent a score of 1–3.
I (Intermediate):	Would generally represent a score of 4–5.
R (Resistant):	Would generally represent a score of 6–7.
H (Highly Resistant):	Would generally represent a score of 8–9. Highly resistant does not imply the inbred is immune.
J. Variety Most Closely Resembling:	
Character	Hybrid
Maturity	Pioneer Brand 3379
Usage	Pioneer Brand 3379

*If maximum is greater than 86 degrees fahrenheit, then 86 is used and if minimum is less than 50, then 50 is used. Heat units accumulated daily and can not be less than 0.

Items B, C, D, E, F, and G are based on a maximum of two reps of data primarily from Johnston, Iowa in 1990.

This invention includes the hybrid corn seed of 3394, the hybrid corn plant produced from the hybrid corn seed, and variants, mutants, and modifications of 3394. This invention also relates to the use of 3394 in producing three-way and double cross hybrids.

The terms variant, trivial modification, and mutant refer to a hybrid seed where a plant produced by that hybrid seed which is phenotypically similar to 3394.

As used herein, the term "plant" includes plant cells, plant protoplast, plant cell or tissue culture from which corn plants can be regenerated, plant calli, plant clumps and plant cells that are intact in plants or parts of plants, such as flowers, kernels, ears, cobs, leaves, husks, stalks and the like.

Tissue culture of corn is described in European Patent Application, publication number 160,390, incorporated herein by reference. Corn tissue culture procedures are also described in Green and Rhodes, "Plant Regeneration in Tissue Culture of Maize," *Maize for Biological Research*, (Plant Molecular Biology Association, Charlottesville, Va. 1982) at 367–372 and in Duncan, et al., "The Production of Callus Capable of Plant Regeneration from Immature Embryos of Numerous Zea Mays Genotypes," 165 *Planta* 322–332 (1985).

USES OF CORN

Corn is used as human food, livestock feed, and as raw material in industry. The food uses of corn, in addition to human consumption of corn kernels, include both products of dry- and wet-milling industries. The principal products of corn dry milling are grits, meal and flour. The corn wet-milling industry can provide starch, syrups, and dextrose for food use. Corn oil is recovered from corn germ, which is a by-product of both dry- and wet-milling industries.

Corn is also used extensively as livestock feed primarily to beef cattle, dairy cattle, hogs, and poultry.

Industrial uses of corn are mainly from corn starch from the wet-milling industry and corn flour from the dry-milling industry. The industrial applications of corn starch and flour are based on functional properties, such as viscosity, film formation, adhesive properties, and ability to suspend particles. The corn starch and flour have application in the paper and textile industries. Other industrial uses include applications in adhesives, building materials, foundry binders, laundry starches, explosives, oil-well muds, and other mining applications.

Plant parts other than the grain of corn are also used in industry. Stalks and husks are made into paper and wallboard and cobs are used for fuel and to make charcoal.

The seed of 3394, the hybrid corn plant produced from the seed, and various parts of the hybrid corn plant can be utilized for human food, livestock feed, and as a raw material in industry.

EXAMPLE 1

Research Comparisons for Pioneer Hybrid 3394

Comparisons of the characteristics for Pioneer Brand Hybrid 3394 were made against Pioneer Brand Hybrids 3503, 3417, 3398, 3379, 3362, and 3241; Garst Brand Hybrid GR8532; and Wyffel Brand Hybrids WYF670 and WYF627. These hybrids are grown in the Central and Eastern Corn Belt and have similar maturity. Table 1A compares Pioneer Brand 3394 to Pioneer Brand 3503. 3394 has higher yield and grain harvest moisture, but lower test weight than 3503. 3394 is a taller hybrid with higher ear placement and flowers (GDU Shed) later than 3503. Compared to 3503, 3394 has poorer grain appearance, better stay green, better resistance to stalk lodging, but is more susceptible to root lodging and has fewer brittle stalks.

The results in Table 1B compare Pioneer Brand Hybrid 3394 to Pioneer Brand Hybrid 3417. 3394 has higher yield, grain harvest moisture, and test weight than 3417. 3394 is a taller hybrid, has higher ear placement, and flowers (GDU Shed) later than 3417. 3394 is better agronomically than 3417, having better grain appearance and stay green, better stalk lodging resistance and fewer brittle stalks, but is more susceptible to root lodging.

Table 1C results show Pioneer Brand Hybrid 3394 is higher yielding but has lower grain moisture and test weight than Pioneer Brand Hybrid 3398. 3394 has more barren plants, but has better seedling vigor and more plants are established early than 3398. 3394 is taller and has a higher ear placement compared to 3398. 3394 flowers (GDU Shed) later than 3398. 3394 has slightly poorer grain appearance and is more susceptible to root lodging than 3398.

The results in Table 1D compare Pioneer Brand Hybrid 3394 to Pioneer Brand Hybrid 3379. 3394 outyields and has higher test weight but slightly lower grain moisture than 3379. 3394 and 3379 have similar early stand count, but 3394 has better seedling vigor. 3394 has better stay green and is more resistant to stalk and root lodging than 3379.

Table 1E, comparing Pioneer Brand Hybrid 3394 to Pioneer Brand Hybrid 3362, shows 3394 has higher yield, grain moisture, and test weight than 3362. 3394 is a taller hybrid, has higher ear placement, and sheds (GDU Shed) later than 3362. 3394 is more susceptible to root lodging, but has better stay green and stalk lodging resistance than 3362.

Table 1F compares Pioneer Brand 3394 to Pioneer Brand 3241. 3394 has higher yield and test weight and lower grain moisture than 3241. 3394 is shorter with lower ear placement and flowers (GDU Shed) slightly earlier than 3241. Compared to 3241, 3394 has poorer grain appearance, more susceptibility to stalk lodging, more resistance to root lodging, and fewer brittle stalks.

Table 1G results show Pioneer Brand Hybrid 3394 has higher grain yield but lower grain moisture and test weight than Garst Brand Hybrid GR8532. 3394 is significantly taller and has a higher ear placement than GR8532. 3394 flowers (GDU Shed) later than GR8532. 3394 has better stay green and stalk lodging resistance, but is more susceptible to root lodging than GR8532.

Table 1H compares Pioneer Brand Hybrid 3394 to Wyffels Brand Hybrid WYF670. 3394 significantly outyields WYF670 but has similar test weight and lower grain moisture. 3394 is taller with higher ear placement and flowers (GDU Shed) later than WYF670. Agronomically, 3394 is better than WYF670, having better grain appearance, stay green, and stalk and root lodging resistance.

Table 1I, comparing Pioneer Brand Hybrid 3394 to Wyffels Brand Hybrid WYF627, shows 3394 is higher yielding, has higher test weight, but has lower grain moisture than WYF627. 3394 is a taller hybrid and has higher ear placement than WYF627. 3394 flowers (GDU Shed) later than WYF627. 3394 has significantly better stay green and stalk lodging resistance compared to WYF627.

TABLE 1A

VARIETY #1 - 3394
VARIETY #2 - 3503

YEAR	VAR #	BU ACR ABS	BU ACR % MN	MST ABS	PLT HT ABS	EAR HT ABS	SDG VGR ABS	EST CNT ABS	DRP EAR ABS	GDU SHD ABS	TST WTA ABS	GRN APP ABS	STA GRN ABS	STK LDG ABS	RT LDG ABS	BRT STK ABS
89	1	156.9	110	17.0	109.7	46.7	5.9	61.7	97.5	1345	59.2	6.2	5.3	89.9	94.4	
	2	144.2	102	17.5	104.8	43.5	5.9	61.1	98.3	1310	61.2	5.8	5.6	83.1	98.3	
	LOCS	9	9	9	3	3	4	7	5	3	9	9	4	7	5	
	PROB	.005#	.007#	.031+	.041+	.101	.000#	.739	.186	.109	.000#	.486	.724	.087*	.525	
90	1	163.1	111	20.6	98.2	45.6	7.0	60.4	99.5	1443	57.0	7.0	6.6	94.6	96.7	98.7
	2	146.2	99	20.3	91.5	41.0	5.9	57.6	99.8	1375	58.7	7.6	4.4	90.9	97.6	97.5
	LOCS	182	182	182	97	97	103	125	123	60	180	124	99	175	57	9
	PROB	.000#	.000#	.001#	.000#	.000#	.000#	.000#	.029+	.000#	.000#	.000#	.000#	.000#	.461	.086*
TOTAL SUM	1	162.8	111	20.4	98.5	45.7	6.9	60.5	99.4	1438	57.1	7.0	6.6	94.4	96.5	98.7
	2	146.1	100	20.1	91.9	41.1	5.9	57.7	99.7	1372	58.8	7.4	4.4	90.6	97.7	97.5
	LOCS	191	191	191	100	100	107	132	128	63	189	133	103	182	62	9
	DIFF	16.7	11	0.3	6.7	4.6	1.0	2.7	0.3	66	1.8	0.5	2.2	3.8	1.2	1.2
	PROB	.000#	.000#	.004#	.000#	.000#	.000#	.000#	.016+	.000#	.000#	.000#	.000#	.000#	.345	.086*

* = 10% SIG
+ = 5% SIG
# = 1% SIG

TABLE 1B

VARIETY #1 - 3394
VARIETY #2 - 3417

YEAR	VAR #	BU ACR ABS	BU ACR % MN	MST ABS	PLT HT ABS	EAR HT ABS	SDG VGR ABS	EST CNT ABS	DRP EAR ABS	GDU SHD ABS	TST WTA ABS	GRN APP ABS	STA GRN ABS	STK LDG ABS	RT LDG ABS	BRT STK ABS
89	1	159.7	109	18.2	106.6	48.6	5.8	60.9	98.5	1353	58.5	6.3	5.3	92.0	96.2	97.0
	2	154.0	105	17.9	103.4	41.6	5.8	61.2	99.2	1308	57.7	5.7	4.1	81.2	93.6	94.9
	LOCS	18	18	18	8	8	6	12	9	6	18	18	7	15	9	1
	PROB	.174	.181	.209	.011+	.000#	.862	.637	.300	.003#	.021+	.133	.047+	.009#	.124	
90	1	164.3	110	20.3	98.6	45.4	7.0	60.7	99.6	1448	57.0	7.2	6.3	95.1	96.6	97.8
	2	147.7	99	19.6	94.8	37.8	5.8	59.0	99.8	1392	56.8	6.9	4.5	92.1	99.0	93.9
	LOCS	252	252	253	130	130	131	166	161	68	250	161	134	250	80	15
	PROB	.000#	.000#	.000#	.000#	.000#	.000#	.000#	.028+	.000#	.000#	.009#	.000#	.000#	.002#	.095*
TOTAL SUM	1	164.0	110	20.2	99.0	45.6	7.0	60.7	99.5	1440	57.1	7.1	6.3	94.9	96.6	97.7
	2	148.1	99	19.5	95.3	38.0	5.8	59.2	99.7	1385	56.8	6.8	4.5	91.4	98.4	94.2
	LOCS	270	270	271	138	138	137	178	170	74	268	179	141	265	89	16
	DIFF	15.8	10	0.7	3.7	7.6	1.2	1.5	0.2	55	0.3	0.3	1.8	3.5	1.9	3.5
	PROB	.000#	.000#	.000#	.000#	.000#	.000#	.000#	.014+	.000#	.000#	.003#	.000#	.000#	.009#	.108

* = 10% SIG
+ = 5% SIG
# = 1% SIG

TABLE 1C

VARIETY #1 - 3394
VARIETY #2 - 3398

YEAR	VAR #	BU ACR	BU ACR	MST	BAR PLT	PLT HT	EAR HT	SDG VGR	EST CNT	DRP EAR

00055

TABLE 1C-continued

YEAR	#	ABS	% MN	ABS	ABS	ABS	ABS	ABS	ABS	ABS
88	1	105.1	115	19.3	90.9	95.0	41.5	5.8	53.5	100.0
	2	97.2	106	21.3	93.5	87.8	34.3	5.8	60.3	100.0
	LOCS	2	2	2	2	2	2	3	2	2
	PROB	.499	.499	.097*	.156	.109	.022+	.000#	.476	1.00
89	1	172.3	111	19.4		101.0	48.5	6.3	58.5	99.7
	2	152.4	98	20.2		101.7	41.0	6.3	58.4	100.0
	LOCS	8	8	8		3	3	3	5	4
	PROB	.005#	.007#	.056*		.881	.013+	1.00	.960	.391*
90	1	165.0	109	20.5		100.7	44.1	7.1	61.3	99.6
	2	155.1	102	20.9		94.4	38.8	5.8	59.1	99.8
	LOCS	94	94	95		40	40	40	64	67
	PROB	.000#	.000#	.003#		.000#	.000#	.000#	.000#	.119
TOTAL SUM	1	164.4	109	20.4	90.9	100.4	44.3	7.0	60.9	99.7
	2	153.8	102	20.9	93.5	94.6	38.7	5.9	59.0	99.8
	LOCS	104	104	105	2	45	45	46	71	73
	DIFF	10.6	7	0.5	4.5	5.9	5.5	1.1	1.9	0.2
	PROB	.000#	.000#	.000#	.156	.000#	.000#	.000#	.000#	.090*

YEAR	VAR #	GDU SHD ABS	TST WTA ABS	GRN APP ABS	STA GRN ABS	STK LDG ABS	RT LDG ABS	BRT STK ABS
88	1	1453	57.5	7.3	5.2	99.4	98.3	
	2	1413	56.4	6.3	3.8	98.3	100.0	
	LOCS	2	2	2	3	2	2	
	PROB	.156	.296	.000#	.094*	.500	.500	
89	1	1415	57.5	6.3	5.5	91.4	98.8	97.0
	2	1257	57.3	6.3	5.0	77.3	97.0	98.9
	LOCS	3	8	8	3	7	5	1
	PROB	.075*	.714	.000#	.729	.046+	.305	
90	1	1428	57.1	6.7	6.3	95.5	95.4	96.8
	2	1369	57.3	7.0	4.1	92.0	98.2	95.5
	LOCS	21	95	43	33	88	34	9
	PROB	.000#	.013+	.065*	.000#	.003#	.062*	.414
TOTAL SUM	1	1428	57.11	6.6	6.2	95.3	95.9	96.9
	2	1371	57.3	6.8	4.1	91.0	98.2	95.7
	LOCS	26	105	53	38	97	41	10
	DIFF	57	0.2	0.2	2.0	4.2	2.2	1.2
	PROB	.000#	.053*	.163	.000#	.000#	.085*	.484

* = 10% SIG
+ = 5% SIG
# = 1% SIG

TABLE 1D

VARIETY #1 - 3394
VARIETY #2 - 3379

YEAR	VAR #	BU ACR ABS	BU ACR % MN	MST ABS	BAR PLT ABS	PLT HT ABS	EAR HT ABS	SDG VGR ABS	EST CNT ABS	DRP EAR ABS
88	1	125.7	110	20.4	91.4	89.6	39.4	6.2	59.6	99.9
	2	116.3	102	22.3	90.9	88.8	37.9	5.9	64.4	99.9
	LOCS	16	16	16	5	9	9	10	9	13
	PROB	.050*	.075*	.0019	.805	.761	.273	.440	.008#	.700
89	1	162.8	108	20.1		109.9	50.8	6.6	59.7	98.8
	2	154.2	102	19.8		111.1	50.4	5.5	60.1	99.5
	LOCS	43	43	43		18	18	16	28	22
	PROB	.000#	.000#	.064*		.261	.469	.000#	.598	.141
90	1	164.6	109	20.1		100.2	45.7	7.0	59.5	98.6
	2	150.2	100	20.2		100.8	45.1	5.9	59.4	99.7
	LOCS	271	271	272		143	143	141	173	145
	PROB	.000#	.000#	.236		.054*	.036+	.000#	.668	.340
TOTAL SUM	1	162.5	109	20.1	91.4	100.6	45.9	6.9	59.5	99.5
	2	149.1	100	20.3	90.9	101.2	45.3	5.8	59.7	99.7
	LOCS	330	330	331	5	170	170	167	210	180
	DIFF	13.4	9	0.2	0.5	0.6	0.6	1.1	0.2	0.1
	PROB	.000#	.000#	.110	.803	.054*	.015+	.000#	.507	.002

YEAR	VAR #	GDU SHD ABS	TST WTA ABS	GRN APP ABS	STA GRN ABS	STK LDG ABS	RT LDG ABS	BRT STK ABS
88	1	1441	57.3	8.0	4.9	94.3	96.2	100.0

00059

TABLE 1D-continued

	2	1444	56.5	7.6	5.2	90.3	70.5	100.0
	LOCS	5	16	13	9	15	5	1
	PROB	.872	.0018	.213	.665	.234	.231	
89	1	1364	57.3	6.1	6.0	92.4	97.2	98.0
	2	1353	56.6	6.4	5.0	91.6	92.6	99.5
	LOCS	14	43	38	14	36	17	2
	PROB	.086*	.0008	.249	.725*	.557	.256*	.166
90	1	1438	57.0	7.3	6.1	94.5	96.5	97.7
	2	1434	57.0	7.2	5.1	94.3	95.5	96.5
	LOCS	76	267	180	159	258	69	16
	PROB	.171	.725	.758	.0008	.724	.141	.216
TOTAL SUM	1	1427	57.1	7.1	6.0	94.3	96.6	97.8
	2	1423	56.9	7.1	5.1	93.8	93.6	97.0
	LOCS	95	326	231	182	309	91	19
	DIFF	04	0.1	0.0	0.0	0.4	3.0	0.8
	PROB	.076*	.0088	.948	.0008	.370	.018+	.304

* = 10% SIG
+ = 5% SIG
# = 1% SIG

TABLE 1E

VARIETY #1 - 3394
VARIETY #2 - 3362

YEAR	VAR #	BU ACR ABS	BU ACR % MN	MST ABS	FLT HT ABS	EAR HT ABS	SDG VGR ABS	EST CNT ABS	DRP EAR ABS	GDU SHD ABS	TST WTA ABS	GRN APP ABS	STA GRN ABS	STK LDG ABS	RT LDG ABS	BRT STK ABS
89	1	164.1	109	19.9	103.9	50.5	6.6	59.4	99.0	1369	57.3	6.6	6.2	90.6	95.3	97.0
	2	149.4	100	19.8	102.4	47.3	5.0	57.3	98.8	1336	56.9	6.0	3.8	80.2	94.6	99.1
	LOCS	21	21	21	8	8	9	12	14	8	21	16	5	20	9	1
	PROB	.007#	.009#	.786	.251	.091*	.016+	.200	.543	.006#	.012+	.250	.054*	.005#	.533	
90	1	162.8	110	20.1	98.1	44.8	7.0	60.6	99.5	1446	57.2	7.1	6.3	94.9	96.4	97.8
	2	143.7	98	19.7	95.0	41.6	5.5	58.2	99.7	1413	56.5	7.0	4.4	91.3	97.9	97.1
	LOCS	221	221	222	115	115	121	148	139	70	220	130	121	212	77	17
	PROB	.000#	.000#	.001#	.000#	.000#	.000#	.000#	.007*	.000#	.000#	.576	.000#	.000#	.012+	.472
TOTAL SUM	1	162.9	110	20.1	98.5	45.2	6.9	60.5	99.5	1438	57.2	7.0	6.3	94.5	96.3	97.8
	2	144.2	98	19.7	95.5	42.0	5.5	58.2	99.6	1405	56.5	6.9	4.4	90.3	97.6	97.2
	LOCS	242	242	243	123	123	128	160	153	78	241	146	126	221	86	18
	DIFF	18.8	12	0.4	3.0	3.2	1.4	2.4	0.2	33	0.6	0.1	1.9	4.2	1.3	0.6
	PROB	.000#	.000#	.001#	.000#	.000#	.000#	.000#	.109	.000#	.000#	.366	.000#	.000#	.020+	.548

* = 10% SIG
+ = 5% SIG
# = 1% SIG

TABLE 1F

VARIETY #1 - 3394
VARIETY #2 - 3241

YEAR	VAR #	BU ACR ABS	BU ACR % MN	MST ABS	FLT HT ABS	EAR HT ABS	SDG VGR ABS	EST CNT ABS	DRP EAR ABS	GDU SHD ABS	TST WTA ABS	GRN APP ABS	STA GRN ABS	STK LDG ABS	RT LDG ABS	BRT STK ABS
88	1	136.5	109	20.8	70.5	34.5	5.0		100.0		57.4	8.3	6.0	92.6	93.4	
	2	146.5	118	23.2	79.5	39.0	6.0		100.0			56.3	7.8	4.0	97.4	46.2
	LOCS	6	6	6	2	2	1		5							
	PROB	.466	.441	.016+	.205	.205			1.00		.137	.580		.207	.456	
89	1	173.8	107	24.2	110.0	54.0	7.5	57.4	99.7	1418	55.1	5.8	6.7	92.5	98.0	98.9
	2	171.1	105	25.3	115.3	57.3	6.9	57.1	100.0	1398	55.0	7.1	6.8	96.2	90.4	97.8
	LOCS	15	15	15	6	6	4	9	7	5	15	15	6	14	7	1
	PROB	.508	.532	.000#	.099*	.063*	.239	.891	.173	.247	.634	.001#	.856	.058*	.169	
90	1	170.0	109	21.7	101.4	47.8	7.2	57.0	99.8	1428	56.2	7.1	6.2	94.2	99.4	
	2	164.2	105	23.9	107.4	50.3	7.0	56.8	99.7	1441	55.7	7.6	6.4	95.1	97.0	
	LOCS	93	93	93	47	47	38	57	51	24	91	82	62	90	10	
	PROB	.000#	.000#	.000#	.000#	.000#	.168	.682	.385	.015+	.000#	.000#	.260	.352	.077*	
TOTAL SUM	1	168.7	109	22.0	101.2	48.0	7.2	57.1	99.8	1426	56.1	7.0	6.2	93.9	98.3	98.9
	2	164.1	106	24.0	107.2	50.7	7.0	56.8	99.8	1433	55.6	7.5	6.4	95.4	89.2	97.8
	LOCS	114	114	114	55	55	43	66	63	29	112	103	69	109	19	1

00060

TABLE 1F-continued

VARIETY #1 - 3394
VARIETY #2 - 3241

DIFF.	4.6	3	2.0	6.1	2.7	0.3	0.2	0.1	08	0.5	0.5	0.2	1.4	9.1	1.1
PROB	.002#	.004#	.000#	.000#	.000#	.127	.575	.556	.165	.000#	.000#	.340	.083*	.075*	

* = 10% SIG
+ = 5% SIG
# = 1% SIG

TABLE 1G

VARIETY #1 - 3394
VARIETY #2 - GR8532

YEAR	VAR #	BU ACR ABS	BU ACR % MN	MST ABS	PLT HT ABS	EAR HT ABS	SDG VGR ABS	EST CNT ABS	DRP EAR ABS	GDU SHD ABS	TST WTA ABS	GRN APP ABS	STA GRN ABS	STK LDG ABS	RT LDG ABS	BRT STK ABS
90	1	162.5	110	19.5	94.4	46.1	6.7	61.7	99.5	1445	57.2	7.2	6.2	93.2	96.5	99.1
	2	137.1	93	20.9	83.4	37.9	5.6	60.7	99.8	1347	57.5	7.3	4.1	89.3	98.3	99.1
	LOCS	94	94	94	55	55	67	70	64	32	92	63	56	92	34	7
	PROB	.000#	.000#	.000#	.000#	.000#	.000#	.044+	.064*	.000#	.008#	.572	.000#	.001#	.131	.961
TOTAL SUM	1	162.5	110	19.5	94.4	46.1	6.7	61.7	99.5	1445	57.2	7.2	6.2	93.2	96.5	99.1
	2	137.1	93	20.9	83.4	37.9	5.6	60.7	99.8	1347	57.5	7.3	4.1	89.3	98.3	99.1
	LOCS	94	94	94	55	55	67	70	64	32	92	63	56	92	34	7
	DIFF	25.4	17	1.4	11.1	8.2	1.1	1.1	0.3	98	0.3	0.1	2.1	3.8	1.8	0.0
	PROB	.000#	.000#	.000#	.000#	.000#	.000#	.044+	.064*	.000#	.008#	.572	.000#	.001#	.131	.961

* = 10% SIG
+ = 5% SIG
# = 1% SIG

TABLE 1H

VARIETY #1 - 3394
VARIETY #2 - WYN670

YEAR	VAR #	BU ACR ABS	BU ACR % MN	MST ABS	BAR PLT ABS	PLT HT ABS	EAR HT ABS	SDG VGR ABS	EST CNT ABS	DRP EAR ABS
88	1	108.7	113	20.4	90.4	94.3	41.7	5.6	58.6	99.6
	2	94.9	99	22.9	94.0	83.5	32.7	5.6	61.8	100.0
	LOCS	5	5	5	3	3	3	4	4	3
	PROB	.010+	.004#	.025+	.163	.000#	.102	.000#	.375	.423
89	1	155.5	107	18.3		110.2	50.5	6.4	61.4	98.4
	2	137.2	94	20.2		98.9	41.4	6.2	60.3	99.9
	LOCS	20	20	20		9	9	7	12	14
	PROB	.000#	.000#	.000#		.000#	.000#	.766	.274	.005#
98	1	163.2	110	20.0		102.0	45.2	7.1	59.4	99.5
	2	139.3	94	20.9		90.5	36.8	5.9	58.2	99.8
	LOCS	119	119	119		64	64	70	83	60
	PROB	.000#	.000#	.000#		.000#	.000#	.000#	.010+	.056*
TOTAL SUM	1	160.2	110	19.8	90.4	102.7	45.7	6.9	59.6	99.3
	2	137.5	94	20.9	94.0	91.2	37.2	5.9	58.6	99.9
	LOCS	144	144	144	3	76	76	81	99	77
	DIFF	22.7	16	1.1	3.6	11.5	8.5	1.1	1.0	0.5
	PROB	.000#	.000#	.000#	.163	.000#	.000#	.000#	.018+	.001#

YEAR	VAR #	GDU SHD ABS	TST WTA ABS	GRN APP ABS	STA GRN ABS	STK LDG ABS	RT LDG ABS	BRT STK ABS
88	1	1432	57.2	7.3	4.5	94.6	98.1	
	2	1355	55.5	6.0	5.1	99.3	100.0	
	LOCS	3	5	5	4	5	3	
	PROB	.175	.002#	.019+	.703	.430	.196	
89	1	1317	58.5	6.4	5.6	92.6	95.8	97.0
	2	1254	58.6	5.9	4.3	84.1	92.7	100.0
	LOCS	5	20	20	5	15	8	1
	PROB	.007#	.587	.102	.019+	.018+	.303	
90	1	1448	57.2	7.2	6.2	95.0	96.6	99.2
	2	1371	57.5	6.9	4.1	91.2	95.5	99.3
	LOCS	39	118	80	71	109	30	7

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TABLE 1H-continued

TOTAL SUM	PROB	.000#	.049*	.011*	.000#	.000#	.384	.821
	1	1433	57.4	7.1	6.1	94.9	96.5	98.9
	2	1357	57.6	6.6	4.1	90.7	95.3	99.4
	LOCS	47	143	105	80	129	41	8
	DIFF	76	0.1	0.4	2.0	4.2	1.3	0.5
	PROB	.000#	.187	.001#	.000#	.000#	.242	.447

* = 10% SIG
- = 5% SIG
= 1% SIG

TABLE 1I

VARIETY #1 - 3394
VARIETY #2 - WYF627

YEAR	VAR #	BU ACR ABS	BU ACR % MN	MST ABS	PLT HT ABS	EAR HT ABS	SDG VGR ABS	EST CNT ABS	DRP EAR ABS	GDU SHD ABS	TST WTA ABS	GRN APP ABS	STA GRN ABS	STK LDG ABS	RT LDG ABS	BRT STK ABS
89	1	146.7	104	17.8	125.0	53.8	7.2	62.5	98.2	1280	58.9	6.3		98.0	100.0	
	2	129.9	91	18.3	116.8	50.5	7.0	59.2	99.0	1230	58.5	6.3		96.0	100.0	
	LOCS	5	5	5	2	2	3	3	5	1	5	5		2	1	
	PROB	.019*	.032*	.100	.170	.234	.742	.063*	.341		.451	.000#		.291		
90	1	157.8	110	21.9	101.1	46.0	6.8	56.8	99.5	1446	56.2	7.1	6.4	94.9	97.2	100.0
	2	143.0	99	22.3	98.1	43.9	6.0	57.5	99.6	1427	55.5	6.8	3.5	87.1	97.0	100.0
	LOCS	57	57	57	23	23	26	22	36	14	57	55	26	57	17	2
	PROB	.000#	.000#	.073*	.003#	.002#	.008#	.443	.563	.017*	.000#	.270	.000#	.000#	.610	1.00
TOTAL	1	156.9	110	21.6	103.0	46.6	6.8	57.3	99.3	1433	56.4	7.0	6.4	95.0	97.4	100.0
SUM	2	141.6	99	21.9	99.6	44.4	6.1	57.8	99.5	1414	55.8	6.8	3.5	87.4	97.1	100.0
	LOCS	62	62	62	25	25	29	25	41	15	62	60	26	59	18	2
	DIFF	15.0	11	0.4	3.4	2.2	0.7	0.3	0.2	21	0.6	0.2	2.9	7.5	0.3	0.0
	PROB	.000#	.000#	.048-	.001#	.001#	.007#	.683	.343	.008#	.000#	.287	.000#	.000#	.609	1.00

* = 10% SIG
- = 5% SIG
= 1% SIG

EXAMPLE 2

Strip Test Data for Hybrid 3394

Comparison data was collected from strip tests that were grown by farmers. Each hybrid was grown in strips of 4, 6, 8, 12, etc. rows in fields depending on the size of the planter used. The data was collected from strip tests that had the hybrids in the same area and weighed. The moisture percentage was determined and bushels per acre was adjusted to 15.5 percent moisture. The number of comparisons represent the number of locations or replications for the two hybrids that were grown in the same field in close proximity and compared.

Comparison strip testing was done between Pioneer Brand Hybrid 3394 and Pioneer Brand Hybrids 3503, 3417, 2398, 3379, 3362, and 3241; Garst Brand Hybrid 8532; and Wyffels Brand Hybrid WYF670. The comparisons came from all the hybrid's adapted growing areas in the United States.

These results are presented in Table 2. The results show Pioneer Brand Hybrid 3394 had a yield advantage over compared hybrids except Pioneer Hybrid 3398 where it had a disadvantage of 2.8 bushels per acre. 3394 had a slight moisture disadvantage against Pioneer Hybrids 3503, 3417, and 3362, and Garst Hybrid 8532. 3394 showed a greater income advantage to the farmer based on adjusted gross income over all hybrids compared except Pioneer Hybrid 3398 where the disadvantage was $4.18 per acre. With the exception of Pioneer Hybrid 3398, 3394's yield and income advantage plus its advantage for other characteristics over these hybrids will make it an important addition for most of the areas where these hybrids are grown.

TABLE 2

PIONEER HYBRID 3394 VS PIONEER HYBRIDS 3503, 3417, 3398, 3379, 3362, AND 3241; GARST HYBRID GR8532; AND WYFFELS WYF670 FROM 1990 STRIP TESTS

Brand	Product	Yield	Moist	Income/ Acre	Pop K/Acre	Stand (%)	Roots (%)	Test Wt
PIONEER	3394	167.8	19.4	402.22	23.2	92	98	56.7
PIONEER	3503	154.6	19.1	371.57	22.9	87	96	58.5
Advantage		13.2	-0.3	30.65	0.3	5	2	-1.8
Number of Comparisons		159	159	159	85	68	40	133
Percent Wins		87	40	83	54	45	5	6
Probability of Difference		99	99	99	85	99	65	99
PIONEER	3394	169.3	19.4	405.74	23.6	91	98	56.7
PIONEER	3417	160.1	18.8	385.83	23.4	88	98	56.3
Advantage		9.2	-0.6	19.91	0.2	3	0	0.4
Number of Comparisons		245	245	245	145	116	87	200
Percent Wins		75	28	72	46	55	5	56
Probability of Difference		99	99	99	84	99	2	99
PIONEER	3394	162.6	17.7	395.41	22.1	96	100	57.3
PIONEER	2398	164.4	18.2	399.59	21.9	98	100	57.1
Advantage		-2.8	0.5	-4.18	0.2	-2	0	0.2
Number of Comparisons		37	37	37	20	11	7	36
Percent Wins		32	64	40	45	18	0	44
Probability of Difference		92	97	68	20	63	0	67
PIONEER	3394	167.1	19.4	400.61	23.6	92	98	56.9
PIONEER	3379	155.0	19.4	371.71	23.7	93	98	56.5
Advantage		12.1	0.0	28.90	-0.1	-1	0	0.4
Number of Comparisons		343	343	343	217	172	122	282
Percent Wins		85	45	86	41	37	11	52
Probability of Difference		99	41	99	44	89	3	99
PIONEER	3394	167.6	18.8	404.01	23.3	90	99	57.0
PIONEER	3362	153.6	18.4	371.89	22.5	88	99	56.4
Advantage		14.0	-0.4	32.12	0.8	2	0	0.6
Number of Comparisons		191	191	191	109	90	75	150
Percent Wins		91	37	92	59	54	2	61
Probability of Difference		99	99	99	99	97	35	99
PIONEER	3394	170.4	19.7	407.79	24.3	95	98	57.1
PIONEER	3241	161.8	22.7	375.08	23.8	94	95	56.0
Advantage		8.6	3.0	32.71	0.5	1	3	1.1
Number of Comparisons		130	130	130	95	61	43	105
Percent Wins		73	96	85	53	47	15	71
Probability of Difference		99	99	99	93	54	77	99
PIONEER	3394	136.4	25.9	308.72	23.2	90	100	55.5
GARST	8532	113.3	25.5	258.72	24.2	77	100	55.0
Advantage		23.1	-0.4	50.00	-1.0	13	0	0.5
Number of Comparisons		3	3	3	2	2	2	2
Percent Wins		66	66	66	0	50	0	50
Probability of Difference		58	28	60	50	36	0	50
PIONEER	3394	168.2	22.0	392.84	20.5	95	100	50.0
WYFFELS	W670	149.9	23.7	344.68	25.0	92	100	55.0
Advantage		18.3	1.7	48.16	-4.5	3	0	-5.0
Number of Comparisons		6	6	6	1	1	1	1
Percent Wins		83	83	83	0	100	0	0
Probability of Difference		97	84	97	0	0	0	0
PIONEER	3394	167.9	19.3	402.93	23.6	92	98	56.9
WEIGHTED AVG		156.8	19.5	375.69	23.3	91	98	56.7
Advantage		11.1	0.2	27.24	0.3	1	0	0.2
Number of Comparisons		1114	1114	1114	674	521	379	909
Percent Wins		81	46	82	48	46	7	48
Probability of Difference		99	99	99	99	99	81	99

NOTE. The probability values are useful in analyzing if there is a "real" difference in the genetic potential of the products involved. High values are desirable, with 95% considered significant for real differences.

EXAMPLE 3

Comparison of Key Characteristics for Hybrid 3394

Characteristics of Pioneer Brand Hybrid 3394 are compared to Pioneer Brand Hybrids 3503, 3417, 3398, 3379, 3362, and 3241; Garst Brand Hybrid GR8532; and Wyffel Brand Hybrids WYF627 and WYF670 in Table 3. The ratings given for most of the traits are on a 1–9 basis. In these cases 9 would be outstanding, while 1 would be poor for the given characteristics. These values are based on performance of a given hybrid relative to other Pioneer commercial, precommercial, and competitive hybrids that are grown in research and strip test trials. The traits characterized in Table 3 were defined previously and the ratings utilized not only research data but experience trained corn researchers had in the field as well as sales experience with the hybrids in strip test and the field. These scores reflect the hybrid's relative performance to other hybrids for the characteristics listed. The table shows 3394 yielded well for its maturity, yielding equally well at both high and low plant population densities. 3394 has very good stay green and seedling vigor

compared to the other hybrids. 3394 is shorter compared to the other hybrids except Pioneer Hybrid 3241. 3394 has overall excellent yield and agronomic characteristics which should make it an important hybrid in its area of adaptation.

TABLE 3

HYBRID PATENT COMPARISONS--CHARACTERISTICS
Pioneer Hybrid 3394 vs Pioneer Hybrids 3503, 3417, 3398, 3379, 3362, and 3241;
Garst Hybrid 8532; and Wyffel Hybrids WYF627 and WYF670

HYBRID	SILK_CRM	GDU_SILK	BL._CRM	GDU_BL	CRM	YLD	H/POP	L/POP	D/D	S/L
3394	109	1442	110	2760	111	9	9	9	6	7
3503	107	1413	106	2698	109	8	8	7	5	4
3417	108	1423	110	2760	108	9	8	9	6	4
3398	108	1435	109	2756	111	9	8	9	5	6
3379	112	1473	116	2856	111	8	9	6	8	7
3362	111	1462	110	2767	111	8	9	6	6	5
3241	112	1478	113	2806	114	8	8	6	4	8
GR8532	105				113	8	8	6	3	4
WYF627	108	1435	108	2739	111	7	5	7	5	3
WYF670	106	1399	107	2714	113	7	8	6	3	4

HYBRID	R/L	STGR	D/T	T/WT	G/A	S/VIG	P/NT	E/NT	D/E	B/STK
3394	7	8	7	5	6	8	5	4	4	4
3503	6	6	7	8	6	6	3	3	6	5
3417	6	4	8	5	5	5	4	2	6	4
3398	6	3	8	5	7	5	4	3	6	6
3379	5	7	8	5	5	4	4	5	6	7
3362	7	6	9	4	4	4	4	3	6	8
3241	4	8	7	5	6	9	7	8	5	3
GR8532	7	5	8	5	4	5	2	1	5	7
WYF627	3	2	4	4	4	4	4	5	4	
WYF670	7	5	8	5	4	8	2	1	5	7

Although the foregoing invention has been described in some detail by way of illustration and example for purposes of clarity and understanding, it will be obvious that certain changes and modifications may be practiced within the scope of the invention, as limited only by the scope of the appended claims.

Deposits

Applicant has made a deposit of at least 2500 seeds of Hybrid Corn Line 3394 with the American Type Culture Collection (ATCC), Rockville, Md. 20852 USA. ATCC Deposit No. 97224. The seeds deposited with the ATCC on July 17, 1995 were taken from the deposit maintained by Pioneer Hi-Bred International, Inc., 700 Capital Square, 400 Locust Street, Des Moines, Iowa 50309-2340 since prior to the filing date of this application. This deposit of the Hybrid Corn Line 3394 will be maintained in the ATCC depository, which is a public depository, for a period of 30 years, or 5 years after the most recent request, or for the effective life of the patent, whichever is longer, and will be replaced if it becomes nonviable during that period. Additionally, Applicant has satisfied all the requirements of 37 C.F.R. §§1.801 - 1.809, including providing an indication of the viability of the sample. Applicant imposes no restrictions on the availability of the deposited material from the ATCC; however, Applicant has no authority to waive any restrictions imposed by law on the transfer of biological material or its transportation in commerce. Applicant does not waive any infringement of its rights granted under this patent.

What is claimed is:

1. A hybrid corn plant designated as 3394 and its parts, and having ATCC accession number 97224.

2. A tissue culture of regenerable cells of the plant of claim 1 wherein the plants regenerated from the culture have all the physiological and morphological characteristics of 3394.

3. A corn plant regenerated from the tissue culture of claim 2 and having all the physiological and morphological characteristics of hybrid 3394.

4. A tissue culture of a plant according to claim 2, wherein the tissue is selected from the group consisting of leaves, pollen, embryos, roots, root tips, anthers, silk, flowers, kernels, ears, cobs, husks, stalks, cells, and protoplasts thereof.

5. A hybrid corn plant having all the physiological and morphological characteristics of 3394, ATCC accession number 97224.

6. Seed produced by a hybrid corn plant designated as 3394, said hybrid corn plant having ATCC accession number 97224.

* * * * *

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U.S. Patent No. 5,506,367 (inbred corn line)

US005506367A

United States Patent [19]

Keaschall

[11] Patent Number: 5,506,367

[45] Date of Patent: Apr. 9, 1996

[54] **INBRED CORN LINE PHP38**

[75] Inventor: Joseph W. Keaschall, Sharpsville, Ind.

[73] Assignee: Pioneer Hi-Bred International, Inc., Des Moines, Iowa

[21] Appl. No.: 996,378

[22] Filed: Dec. 23, 1992

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 542,364, Jun. 20, 1990, abandoned.

[51] Int. Cl.[6] A01H 5/00; A01H 11/00; C12H 5/04

[52] U.S. Cl. 800/200; 800/250; 800/DIG. 56; 435/240.4; 435/240.45; 435/240.49

[58] Field of Search 800/200, 250, 800/DIG. 56; 47/58.03, 58.05; 435/172.2, 240.4, 240.85, 240.49

[56] **References Cited**

PUBLICATIONS

Phillips et al. (1988) Cell/Tissue Culture and In Vitro Manipulation: In corn & corn Improvement. Ed. Sprague et al. pp. 345–387.

Primary Examiner—Gary Benzion

Attorney, Agent, or Firm—Michael J. Roth; Nina L. Peardmuter

[57] **ABSTRACT**

According to the invention, there is provided an inbred corn line, designated PHP38. This invention thus relates to the plants and seeds of inbred corn line PHP38 and to methods for producing a corn plant produced by crossing the inbred line PHP38 with itself or with another corn plant. This invention further relates to hybrid corn seeds and plants produced by crossing the inbred line PHP38 with another corn line or plant and to crosses with related species.

6 Claims, No Drawings

INBRED CORN LINE PHP38

This is a continuation-in-part of application Ser. No. 07/542,364 filed on Jun. 20, 1990 now abandoned.

FIELD OF THE INVENTION

This invention is in the field of corn breeding, specifically relating to an inbred corn line designated PHP38.

BACKGROUND OF THE INVENTION

The goal of plant breeding is to combine in a single variety/hybrid various desirable traits. For field crops, these traits may include resistance to diseases and insects, tolerance to heat and drought, reducing the time to crop maturity, greater yield, and better agronomic quality. With mechanical harvesting of many crops, uniformity of plant characteristics such as germination and stand establishment, growth rate, maturity, and fruit size, is important.

Field crops are bred through techniques that take advantage of the plant's method of pollination. A plant is self-pollinated if pollen from one flower is transferred to the same or another flower of the same plant. A plant is cross-pollinated if the pollen comes from a flower on a different plant.

Plants that have been self-pollinated and selected for type for many generations become homozygous at almost all gene loci and produce a uniform population of true breeding progeny. A cross between two homozygous lines produce a uniform population of hybrid plants that may be heterozygous for many gene loci. A cross of two plants each heterozygous at a number of gene loci will produce a population of hybrid plants that differ genetically and will not be uniform.

Corn plants (*Zea mays* L.) can be bred by both self-pollination and cross-pollination techniques. Corn has separate male and female flowers on the same plant, located on the tassel and the ear, respectively. Natural pollination occurs in corn when wind blows pollen from the tassels to the silks that protrude from the tops of the incipient ears.

The development of corn hybrids requires the development of homozygous inbred lines, the crossing of these lines, and the evaluation of the crosses. Pedigree breeding and recurrent selection breeding methods are used to develop inbred lines from breeding populations. Breeding programs combine the genetic backgrounds from two or more inbred lines or various other broad-based sources into breeding pools from which new inbred lines are developed by selfing and selection of desired phenotypes. The new inbreds are crossed with other inbred lines and the hybrids from these crosses are evaluated to determine which of those have commercial potential.

Pedigree breeding starts with the crossing of two genotypes, each of which may have one or more desirable characteristics that is lacking in the other or which complement the other. If the two original parents do not provide all of the desired characteristics, other sources can be included in the breeding population. In the pedigree method, superior plants are selfed and selected in successive generations. In the succeeding generations the heterozygous condition gives way to homogeneous lines as a result of self-pollination and selection. Typically in the pedigree method of breeding five or more generations of selfing and selection is practiced: $F_1 \rightarrow F_2$; $F_2 \rightarrow F_3$; $F_3 \rightarrow F_4$; $F_4 \rightarrow F_5$, etc.

Backcrossing can be used to improve an inbred line. Backcrossing transfers a specific desirable trait from one inbred or source to an inbred that lacks that trait. This can be accomplished for example by first crossing a superior inbred (A) (recurrent parent) to a donor inbred (non-recurrent parent), which carries the appropriate gene(s) for the trait in question. The progeny of this cross is then mated back to the superior recurrent parent (A) followed by selection in the resultant progeny for the desired trait to be transferred from the non-recurrent parent. After five or more backcross generations with selection for the desired trait, the progeny will be heterozygous for loci controlling the characteristic being transferred, but will be like the superior parent for most or almost all other genes. The last backcross generation would be selfed to give pure breeding progeny for the gene(s) being transferred.

A single cross hybrid corn variety is the cross of two inbred lines, each of which has a genotype which complements the genotype of the other. The hybrid progeny of the first generation is designated F_1. In the development of hybrids only the F_1 hybrid plants are sought. Preferred F hybrids are more vigorous than their inbred parents. This hybrid vigor, or heterosis, can be manifested in many polygenic traits, including increased vegetative growth and increased yield.

The development of a hybrid corn variety involves three steps: (1) the selection of plants from various germplasm pools; (2) the selfing of the selected plants for several generations to produce a series of inbred lines, which, although different from each other, each breed true and are highly uniform; and (3) crossing the selected inbred lines with unrelated inbred lines to produce the hybrid progeny (F_1). During the inbreeding process in corn, the vigor of the lines decreases. Vigor is restored when two unrelated inbred lines are crossed to produce the hybrid progeny (F_1). An important consequence of the homozygosity and homogeneity of the inbred lines is that the hybrid between any two inbreds will always be the same. Once the inbreds that give a superior hybrid have been identified, the hybrid seed can be reproduced indefinitely as long as the homogeneity of the inbred parents is maintained.

A single cross hybrid is produced when two inbred lines are crossed to produce the F_1 progeny. A double cross hybrid is produced from four inbred lines crossed in pairs (A×B and C×D) and then the two F_1 hybrids are crossed again (A×B)×(C×D). Much of the hybrid vigor exhibited by F_1 hybrids is lost in the next generation (F_2). Consequently, seed from hybrid varieties is not used for planting stock.

Corn is an important and valuable field crop. Thus, a continuing goal of plant breeders is to develop high-yielding corn hybrids that are agronomically sound based on stable inbred lines. The reasons for this goal are obvious: to maximize the amount of grain produced with the inputs used and minimize susceptibility to environmental stresses. To accomplish this goal, the corn breeder must select and develop superior inbred parental lines for producing hybrids. This requires identification and selection of genetically unique individuals which in a segregating population occur as the result of a combination of crossover events plus the independent assortment of specific combinations of alleles at many gene loci which results in specific genotypes. Based on the number of segregating genes, the frequency of occurrence of an individual with a specific genotype is less than 1 in 10,000. Thus, even if the entire genotype of the parents has been characterized and the desired genotype is known, only a few if any individuals having the desired genotype may be found in a large F_2 or S_0 population.

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Typically, however, the genotype of neither the parents nor the desired genotype is known in any detail.

SUMMARY OF THE INVENTION

According to the invention, there is provided a novel inbred corn line, designated PHP38. This invention thus relates to the seeds of inbred corn line PHP38, to the plants of inbred corn line PHP38, and to methods for producing a corn plant produced by crossing the inbred line PHP38 with itself or another corn line. This invention further relates to hybrid corn seeds and plants produced by crossing the inbred line PHP38 with another corn line or a related species.

DEFINITIONS

In the description and examples that follow, a number of terms are used herein. In order to provide a clear and consistent understanding of the specification and claims, including the scope to be given such terms, the following definitions are provided:

ABS=absolute measurement and % MN is percentage of mean of the experiments in which inbread or hybrid was grown unless otherwise defined.

BAR PLT=BARREN PLANTS. This is the percent of plants per plot that were not barren (lack ears).

BRT STK=BRITTLE STALKS. This is a measure of the stalk breakage near the time of pollination, and is an indication of whether a hybrid or inbred would snap or break near the time of flowering under severe winds. Data are presented as percentage of plants that did not snap.

BU ACR=YIELD (BUSHELS/ACRE). Actual yield of the grain at harvest adjusted to 15.5% moisture. ABS is in absolute terms and % MN is percent of the means for the experiments in which the inbred or hybrid was grown.

CLD TST=COLD TEST. This is the percentage of kernels that germinate under cold soil conditions.

COB SC=COB SCORE. The cob score is a rating of how well the grain is shelled off the cob and how badly the cob is broken up going through the combine. This is given as a 1 to 9 score with 9 being very good. A high score indicates that the grain shells off of the cob well, and the cob does not break.

DRP EAR=DROPPED EARS. This is a measure of the number of dropped ears per plot and represents the percentage of plants that did not drop ears prior to harvest.

EAR HT=EAR HEIGHT. The ear height is a measure from the ground to the top developed ear node attachment and is measured in inches.

EAR SZ=EAR SIZE. A 1 to 9 visual rating of ear size. The higher the rating the larger the ear size.

EST CNT=EARLY STAND COUNT. This is a measure of the stand establishment in the spring and represents the number of plants that emerge on a per plot basis for the inbred or hybrid.

GDU SHD=GDU TO SHED. The number of growing degree units (GDUs) or heat units required for an inbred line or hybrid to have approximately 50 percent of the plants shedding pollen and is measured from the time of planting. Growing degree units are calculated by the Barger Method, where the heat units for a 24-hour period are:

$$GDU = \frac{(\text{Max. temp} + \text{Min. temp})}{2} - 50$$

The highest maximum temperature used is 86° F. and the lowest minimum temperature used is 50° F. For each inbred or hybrid it takes a certain number of GDUs to reach various stages of plant development.

GDU SLK=GDU TO SILK. The number of growing degree units required for an inbred line or hybrid to have approximately 50 percent of the plants with silk emergence from time of planting. Growing degree units are calculated by the Barger Method as given in GDU SHD definition.

GRN QUL=GRAIN QUALITY. This is a 1 to 9 rating for the general quality of the shelled grain as it is harvested based on such factors as the color of the harvested grain, any mold on the grain, and any cracked grain. High scores indicate good grain quality.

MST=HARVEST MOISTURE. The moisture is the actual percentage moisture of the grain at harvest.

PLT HT=PLANT HEIGHT. This is a measure of the height of the plant from the ground to the tip of the tassel in inches.

POL SC=POLLEN SCORE. A 1 to 9 visual rating indicating the amount of pollen shed. The higher the score the more pollen shed.

PRM=PREDICTED RM. This trait, predicted relative maturity (RM), is based on the harvest moisture of the grain. The relative maturity rating is based on a known set of checks and utilizes standard linear regression analyses and is referred to as the Minnesota Relative Maturity Rating System.

RT LDG=ROOT LODGING. Root lodging is the percentage of plants that do not root lodge; plants that lean from the vertical axis at an approximately 30° angle or greater would be counted as root lodged.

SCT GRN=SCATTER GRAIN. A 1 to 9 visual rating indicating the amount of scatter grain (lack of pollination or kernel abortion) on the ear. The higher the score the less scatter grain.

SDG VGR=SEEDLING VIGOR. This is the visual rating (1 to 9) of the amount of vegetative growth after emergence at the seedling stage (approximately five leaves). A higher score indicates better vigor.

SEL IND=SELECTION INDEX. The selection index gives a single measure of the hybrid's worth based on information for up to five traits. A corn breeder may utilize his or her own set of traits for the selection index. One of the traits that is almost always included is yield. The selection index data presented in the tables represent the mean value averaged across testing stations.

STA GRN=STAY GREEN. Stay green is the measure of plant health near the time of black layer formation (physiological maturity). A high score indicates better late-season plant health.

STK CNT=NUMBER OF PLANTS. This is the final stand or number of plants per plot.

STK LDG=STALK LODGING. This is the percentage of plants that did not stalk lodge (stalk breakage) as measured by either natural lodging or pushing the stalks and determining the percentage of plants that break below the ear.

TAS BLS=TASSEL BLAST. A 1 to 9 visual rating was used to measure the degree of blasting (necrosis due to heat stress) of the tassel at time of flowering. A 1 would indicate a very high level of blasting at time of flowering, while a 9 would have no tassel blasting.

00067

TAS SZ=TASSEL SIZE. A 1 to 9 visual rating was used to indicate the relative size of the tassel. The higher the rating the larger the tassel.

TAS WT=TASSEL WEIGHT. This is the average weight of a tassel (grams) just prior to pollen shed.

TEX EAR=EAR TEXTURE. A 1 to 9 visual rating was used to indicate the relative hardness (smoothness of crown) of mature grain. A 1 would be very soft (extreme dent) while a 9 would be very hard (flinty or very smooth crown).

TILLER=TILLERS. A count of the number of tillers per plot that could possibly shed pollen was taken. Data is given as percentage of tillers: number of tillers per plot divided by number of plants per plot.

TST WT=TEST WEIGHT UNADJUSTED. The measure of the weight of the grain in pounds for a given volume (bushel).

TST WTA=TEST WEIGHT ADJUSTED. The measure of the weight of the grain in pounds for a given volume (bushel) adjusted for percent moisture.

YLD=YIELD. It is the same as BU ACR ABS.

YLD SC=YIELD SCORE. A 1 to 9 visual rating was used to give a relative rating for yield based on plot ear piles. The higher the rating the greater visual yield appearance.

MDM CPX=Maize Dwarf Mosaic Complex (MDMV= Maize Dwarf Mosaic Virus & MCDV=Maize Chlorotic Dwarf Virus): Visual rating (1–9 score) where a "1" is very susceptible and a "9" is very resistant.

COM SMT=Common Smut (*Ustilago maydis*): Percentage of plants that did not have infection.

SLF BLT Southern Leaf Blight (*Bipolaris maydis, Helminthosporium maydis*): Visual rating (1–9 score) where a "1" is very susceptible and a "9" is very resistant.

NLF BLT=Northern Leaf Blight (*Exserohilum turcicum, H. turcicum*): Visual rating (1–9 score) where a "1" is very susceptible and a "9" is very resistant.

COM RST=Common Rust (*Puccinia sorghi*): Visual rating (1–9 score) where a "1" is very susceptible and a "9" is very resistant.

EYE SPT=Eyespot (*Kabatiella zeae*): Visual rating (1–9 score) where a "1" is very susceptible and a "9" is very resistant.

GLF SPT=Gray Leaf Spot (*Cercospora zeae-maydis*): Visual rating (1–9 score) where a "1" is very susceptible and a "9" is very resistant.

STW WLT=Stewart's Wilt (*Erwinia stewartii*): Visual rating (1–9 score) where a "1" is very susceptible and a "9" is very resistant.

HD SMT=Head Smut (*Sphaceiotheca reiliana*): Percentage of plants that did not have infection.

EAR MLD=General Ear Mold: Visual rating (1–9 score) where a "1" is very susceptible and a "9" is very resistant. This is based on overall rating for ear mold of mature ears without determining specific mold organism, and may not be predictive for a specific ear mold.

ECB DPE=Dropped ears due to European Corn Borer (*Ostrinia nubilalis*): Percentage of plants that did not drop ears under second brood corn borer infestation.

ECB 2SC=European Corn Borer Second Brood (*Ostrinia nubilalis*): Visual rating (1–9 score) of post flowering damage due to infestation by European Corn Borer. A "1" is very susceptible and a "9" is very resistant.

ECB 1LF=European Corn Borer First Brood (*Ostrinia nubilalis*): Visual rating (1–9 score) of pre-flowering leaf feeding by European Corn Borer. A "1" is very susceptible and a "9" is very resistant.

DETAILED DESCRIPTION OF THE INVENTION

Inbred corn line PHP38 is a yellow, dent corn inbred that provides an acceptable male or female parental line in crosses for producing first generation F1 corn hybrids. PHP38 is best adapted to the central and eastern regions of the united States. Hybrids of PHP38 also possess very good drought tolerance and stability of yield which makes them extremely well-adapted for the hot, arid growing areas of the Western United States. The inbred can be used to produce hybrids from approximately 111–126 relative maturity based on the Minnesota Relative Maturity Rating System for harvest moisture of grain. PHP38 should make a good female since it has acceptable yield, good early vigor, and good early stand establishment. PHP38 would also be acceptable as a male because of its pollen yield. The inbred in hybrid combination has excellent stay green and overall disease tolerance. PHP38 has excellent stalks and above average roots. PHP38 hybrids generally have very good grain quality and high test weight.

The inbred has shown uniformity and stability within the limits of environmental influence for all the traits as described in the Variety Description Information (Table 1) that follows. Most of the data in the Variety Description Information was collected at Johnston, Iowa. The inbred has been self-pollinated and ear-rowed a sufficient number of generations with careful attention paid to uniformity of plant type to ensure homozygousity and phenotypic stability. The line has been increased both by hand and in isolated fields with continued observation for uniformity. No variant traits have been observed or are expected in PHP38.

Inbred corn line PHP38, being substantially homozygous, can be reproduced by planting seeds of the line, growing the resulting corn plants under self-pollinating or sib-pollinating conditions with adequate isolation, and harvesting the resulting seed, using techniques familiar to the agricultural arts.

TABLE 1

VARIETY DESCRIPTION INFORMATION
INBRED = PHP38

Type: Dent	Region Best Adapted: Central & Eastern Corn Belt
A. Maturity: Average across maturity zones. Zone: 0	
Heat Unit Shed:	1480
Heat Unit Silk:	1500
No. Reps:	64

TABLE 1-continued

VARIETY DESCRIPTION INFORMATION
INBRED = PHP38

HEAT UNITS = $\frac{(\text{Max. Temp. (86° F.)} + \text{Min. Temp (50° F.)})^{*}}{2} - 50$

B. Plant Characteristics:	
Plant height (to tassel tip):	225 cm
Length of top ear internode:	12 cm
Number of ears per stalk:	Single
Ear height (to base of top ear):	82 cm
Number of tillers:	None
Cytoplasm type:	Normal
C. Leaf:	
Color:	(B14) Dark Green
Angle from Stalk:	<30 degrees
Marginal Waves:	(W9) Few
Number of Leaves (mature plants):	20
Sheath Pubescence:	(W22) Light
Longitudinal Creases:	(PA11) many
Length (Ear node leaf):	80 cm
Width (widest point, ear node leaf):	9 cm
D. Tassel:	
Number lateral branches:	8
Branch Angle from central spike:	>45 degrees
Pollen Shed:	Medium based on Pollen yield test (98% of experiment means)
Peduncle Length (top leaf to basal branches):	22 cm
Anther Color:	Red
Glume Color:	Green
E. Ear (Husked Ear Data Except When Stated Otherwise):	
Length:	16 cm
Weight:	121 gm
Mid-point Diameter:	45 mm
Silk Color:	Yellow
Husk Extension (Harvest stage):	(>10 cm) Very long
Husk Leaf:	(8–15 cm) Medium
Taper of Ear:	Average
Position of Shank (dry husks):	Pendent
Kernal Rows:	Straight, Distinct Number = 16
Husk Color (fresh):	Light green
Husk Color (dry):	Buff
Shank Length:	13 cm
Shank (No. of internodes):	8
F. Kernel (Dried):	
Size (from ear mid-point)	
Length:	11 mm
Width:	8 mm
Thick:	6 mm
Shape Grade (% rounds):	40–60 (59% medium round based on Parent Test Data)
Pericarp Color:	Colorless
Aleurone Color:	Homozygous yellow
Endosperm Color:	Yellow
Endosperm Type:	Normal starch
Gm Wt/100 Seeds (unsized):	30 gm
G. Cob:	
Diameter at mid-point:	29 mm
Strength:	Strong
Color:	White
H. Diseases:	
Corn Lethal Necrosis (MCMV = Maize Chlorotic Mottle Virus and MDMV = Maize Dwarf Mosaic Virus):	Resistant
Maize Dwarf mosaic Complex (MDMV & MCDV = Maize Chlorotic Dwarf Virus):	Susceptible
Anthracnose Stalk Rot (*C. graminicola*):	Resistant
S. Leaf Blight (*H. maydis*):	Resistant
N. Leaf Blight (*H. turcicum*):	Intermediate
Carbonum Leaf Blight (*H. carbonum*):	Resistant
Eye Spot (*K. zeae*):	Intermediate
Gray Leaf Spot (*C. zeae*):	Susceptible

TABLE 1-continued

VARIETY DESCRIPTION INFORMATION
INBRED = PHP38

Stewart's Wilt (*E. stewartii*):	Resistant
Goss's Wilt (*C. nebraskense*):	Resistant
Common Smut (*U. maydis*):	Intermediate
Head Smut (*S. reiliana*):	Highly Resistant
Fusarium Ear Mold (*F. moniliforme*):	Resistant
1. Insects:	
European Corn Borer-1 Leaf Damage (Predowering):	Susceptible
European Corn Borer-2 (Post-flowering):	Intermediate
The above descriptions are based on a scale of 1-9, 1 being highly susceptible, 9 being highly resistant.	
S (Susceptible):	Would generally represent a score of 1-3.
I (Intermediate):	Would generally represent a score of 4-5.
R (Resistant):	Would generally represent a score of 6-7.
H (Highly Resistant):	Would generally represent a score of 8-9. Highly resistant does not imply the inbred is immune.
2. Variety Most Closely Resembling:	
Character	Inbred
Maturity	PHK29
Usage	PHG39

*If maximum is greater than 86 degrees fahrenheit, then 86 is used and if minimum is less than 50, then 50 is used. Heat units accumulated daily and can not be less than 0.

Data for Items B, C, D, E, F, and G is based primarily on a maximum of two reps from Johnston, Iowa grown in 1988, plus description information from the maintaining station.

ELECTROPHORESIS RESULTS

Isozyme Genotypes for PHP38

Isozyme data were generated for inbred corn line PHP38 according to the procedures described in Stuber, C. W., Wendel, J. F., Goodman, M. M., and Smith, J. S. C., "Techniques and Scoring Procedures for Starch Gel Electrophoresis of Enzymes from Maize (*Zea mays* L.)", Technical Bulletin No. 286, North Carolina Agricultural Research Service, North Carolina State University, Raleigh, N.C. (1988).

The data in Table 2 compares PHP38 with its parents PHG39 and PHK29.

TABLE 2

ELECTROPHORESIS RESULTS FOR PHP38 AND ITS PARENTS PHG39 AND PHK29

		PARENTS	
Loci	PHP38	PHG39	PHK29
ACP1	4	4	4
ADH1	4	4	4
CAT3	9	9	9
DIA1	8	8	12
GOT1	4	4	4
GOT2	2	2	4
GOT3	4	4	4
IDH1	4	4	4
IDH2	6	6	4
MDH1	6	6	6
MDH2	6	6	3.5
MDH3	16	16	16
MDH4	12	12	12
MDH5	12	12	12
MMM	4	4	4
PGM1	9	9	9
PGM2	4	4	4

TABLE 2-continued

ELECTROPHORESIS RESULTS FOR PHP38 AND ITS PARENTS PHG39 AND PHK29

		PARENTS	
Loci	PHP38	PHG39	PHK29
PGD1	2	2	3.8
PGD2	5	5	5
PH1	4	4	4

INDUSTRIAL APPLICABILITY

This invention also is directed to methods for producing a corn plant by crossing a first parent corn plant with a second parent corn plant wherein the first or second parent corn plant is an inbred corn plant from the line PHP38. Further, both first and second parent corn plants can come from the inbred corn line PHP38. Thus, any such methods using the inbred corn line PHP38 are part of this invention: selfing, backcrosses, hybrid production, crosses to populations, and the like. All plants produced using inbred corn line PHP38 as a parent are within the scope of this invention. Advantageously, the inbred corn line is used in crosses with other, different, corn inbreds to produce first generation (F_1) corn hybrid seeds and plants with superior characteristics.

As used herein, the terms "plant and plant parts" include plant cells, plant protoplasts, plant cell tissue culture from which corn plants can be regenerated, plant calli, plant clumps, and plant cells that are intact in plants or parts of plants, such as embryos, pollen, flowers, kernels, ears, cobs, leaves, husks, stalks, roots, root tips, anthers, silk and the like.

Tissue culture of corn is described in European Patent Application, publication 160,390, incorporated herein by reference. Corn tissue culture procedures are also described in Green and Rhodes, "Plant Regeneration in Tissue Culture of Maize," *Maize for Biological Research* (Plant Molecular Biology Association, Charlottsville, Va. 1982, at 367-372).

Thus, another aspect of this invention is to provide cells which upon growth and differentiation produce the inbred line PHP38.

The utility of inbred line PHP38 also extends to crosses with other species. Commonly, suitable species will be of the family Graminaceae, and especially of the genera Zea, Tripsacum, Coix, Schlerachne, Polytoca, Chionachne, and Trilobachne, of the tribe Maydeae. Of these, Zea and Tripsacum, are most preferred. Potentially suitable for crosses with PHP38 may be the various varieties of grain sorghum, *Sorghum bicolor* (L.) Moench.

Corn is used as human food, livestock feed, and as raw material in industry. The food uses of corn, in addition to human consumption of corn kernels, include both products of dry- and wet-milling industries. The principal products of corn dry milling are grits, meal and flour. The corn wet-milling industry can provide corn starch, corn syrups, and dextrose for food use. Corn oil is recovered from corn germ, which is a by-product of both dry- and wet-milling industries.

Corn, including both grain and non-grain portions of the plant, is also used extensively as livestock feed, primarily for beef cattle, dairy cattle, hogs, and poultry.

Industrial uses of corn are mainly from corn starch from the wet-milling industry and corn flour from the dry-milling industry. The industrial applications of corn starch and flour are based on functional properties, such as viscosity, film formation, adhesive properties, and ability to suspend particles. The corn starch and flour have application in the paper and textile industries. Other industrial uses include applications in adhesives, building materials, foundry binders, laundry starches, explosives, oil-well muds, and other mining applications.

Plant parts other than the grain of corn are also used in industry. Stalks and husks are made into paper and wallboard and cobs are used for fuel and to make charcoal.

The seed of inbred corn line PHP38, the plant produced from the inbred seed, the hybrid corn plant produced from the crossing of the inbred, hybrid seed, and various parts of the hybrid corn plant can be utilized for human food, livestock feed, and as a raw material in industry.

EXAMPLE

INBRED AND HYBRID PERFORMANCE OF PHP38

In the examples that follow the traits and characteristics of inbred corn line PHP38 are given as a line in comparison with its parents and in hybrid combination. The data collected on inbred corn line PHP38 is presented for the key characteristics and traits.

The results in Table 3A compare PHP38 to its PHG39 parent. The results show that PHP38 is significantly higher yielding and has lower grain moisture at maturity than PHG39. PHP38 flowers (GDU SHD and GDU SLK) earlier than PHG39 . PHP38 is shorter with lower ear placement than PHG39 and has significantly fewer barren plants. PHP38 has better seedling vigor, lower early stand establishment and cold tolerance than PHG39 . PHP38 has a higher test weight and scatter grain score than PHG39. In the areas of disease and insect resistance, PHP38 has better agronomic traits, ear mold, Northern leaf blight, and Stewart's wilt resistance but is more susceptible to first brood European corn borer than PHG39.

Table 3B compares PHP38 with inbred PHK29. PHK29 is the other parent of PHP38. PHP38 is lower yielding but has higher test weight than PHK29. PHP38 is shorter, has lower ear placement, and has fewer barren plants than PHK29. The seedling vigor and early stand establishment of PHP38 is better than PHK29 but has fewer kernels germinate under cold soil conditions. PHP38 flowers (GDU SHD and GDU SLK) earlier than PHK29. Stalk lodging, brittle stalk, and Northern and Southern leaf blight resistance is greater for PHP38 but PHP38 is more susceptible to first brood corn borer than PHK29.

Tables 4-9 compare PHP38 hybrids to Pioneer Brand hybrids 3362, 3467, 3540, 3569, 3379, and 3344, respectively. Each hybrid has a parent in common with the PHP38 hybrid other than PHP38. The hybrids are adapted to much of the same area as the PHP38 hybrids. Table 4 compares a PHP38 hybrid with 3362. The PHP38 hybrid yields significantly more bushels per acre and has a higher test weight than 3362. The PHP38 hybrid has better seedling vigor, is shorter, and ear placement is lower than 3362. Stalk lodging resistance is better and the stay green score of the PHP38 hybrid is higher than 3362.

The results of Table 5, comparing the PHP38 hybrid with 3467, show a number of agronomic differences. The PHP38 hybrid yields less, is taller, and has higher ear placement than 3467. The stalk and root lodging resistance of the PHP38 hybrid is better than 3467.

Table 6 shows that the PHP38 hybrid yields more, has higher test weight, and flowers earlier (GDU SHD) than 3540. Root lodging resistance and the stay green score is lower for the PHP38 hybrid and it has more dropped ears than 3540.

Table 7 shows the results between a PHP38 hybrid and 3569. The PHP38 hybrid is slightly higher yielding, has significantly higher test weight, and more grain moisture at maturity than 3569. The PHP38 hybrid and 3569 have similar plant and ear height but the PHP38 hybrid flowers (GDU SHD) slightly earlier than 3569. Stay green and grain quality are significantly better for the PHP38 hybrid than 3569. Stalk lodging resistance is significantly better for the PHP38 hybrid but it is more prone to root lodging than 3569, and the PHP38 hybrid also shows the potential for ear droppage.

The results in Table 8 show the PHP38 hybrid is significantly lower yielding, has significantly higher test weight, and has significantly more grain harvest moisture than 3379. The PHP38 hybrid is shorter, has slightly lower ear placement, and flowers (GDU SHD) similarly compared to 3379. The PHP38 hybrid has better seedling vigor but a lower early stand than 3379. Stay green and stalk lodging resistance are significantly better for the PHP38 hybrid but root lodging resistance is similar compared to 3379.

Table 9 compares a PHP38 hybrid with 3344. The PHP38 hybrid yields slightly more, has higher test weight, and similar grain moisture at maturity compared to 3344. The PHP38 hybrid and 3344 have similar plant and ear height and flower (GDU SHD) similarly. The PHP38 hybrid has significantly better stay green and seedling vigor than 3344. The PHP38 hybrid has better stalks but is slightly more prone to root lodging than 3344, and the PHP38 hybrid also shows the tendency to drop ears. These results show that PHP38 hybrids offer significant advantage over commercial products that are sold for yield and other important agronomic traits.

TABLE 3A

PAIRED INBRED COMPARISON DATA
VARIETY #1 - PHP38
VARIETY #2 - PHO39

YEAR	REGION	VAR #	BU ACR ABS	BU ACR % MN	YLD SC ABS	MST ABS	EAR SZ ABS	BAR PLT ABS	PLT HT ABS	EAR HT ABS	SDG VGR ABS	EST CNT ABS	CLD TST ABS
TOTAL SUM		1	62.5	103	5.8	21.6	5.5	86.3	73.5	29.1	6.8	42.2	75.0
		2	44.5	70	4.7	22.0	6.1	72.4	79.1	33.0	6.1	43.5	94.5
		LOCS	38	38	19	38	13	15	25	25	44	60	2
		DIFF	18.0	33	1.1	0.3	0.5	13.9	5.6	3.9	0.7	1.3	19.5
		PROB	.0009	.0009	.018+	.253	.089*	.041+	.0009	.0009	.0028	.0090	.081*

YEAR	REGION	VAR #	CLD TST % MN	DRP EAR ABS	TIL LER ABS	GDU SHD ABS	GDU SLK ABS	POL SC ABS	TAS BLS ABS	TAS SZ ABS	TEX EAR ABS	TST WT ABS	GRN QUL ABS	SCT GRN ABS
TOTAL SUM		1	93	99.4	1.1	147.1	148.9	5.0	9.0	5.5	6.9	58.1	7.1	5.9
		2	117	99.7	1.5	154.8	157.2	5.5	7.0	5.8	6.3	56.5	7.0	4.7
		LOCS	2	25	19	37	47	15	1	24	10	38	30	15
		DIFF	24	0.3	0.4	7.7	8.4	0.3	2.0	0.3	0.6	1.6	0.2	1.1
		PROB	.080*	.279	.587	.0009	.0009	.262		.139	.239	.0009	.517	.0028

YEAR	REGION	VAR #	STA GRN ABS	STK LDG ABS	KT LDG ABS	BKT STK ABS	EAR MLD ABS	MLF BLT ABS	SLF BLT ABS	STW WLT ABS	ECB DPE ABS	ECB ILF ABS	ECB 2SC ABS
TOTAL SUM		1	6.5	98.3	94.7	98.0	7.4	5.0	7.0	7.0	100.0	3.8	5.8
		2	6.6	97.5	89.2	99.0	6.6	4.0	8.0	4.0	99.6	4.4	5.3
		LOCS	35	31	16	4	17	1	1	2	2	22	18
		DIFF	0.1	0.8	5.5	1.0	0.8	1.0	1.0	3.0	0.4	0.5	0.5
		PROB	.771	.127	.027+	.391	.114			.374	.500	.056*	.446

* = 10% SIG
+ = 5% SIG
@ = 1% SIG

TABLE 3B

PAIRED INBRED COMPARISON DATA
VARIETY #1 - PHP38
VARIETY #2 - PHO29

YEAR	REGION	VAR #	BU ACR ABS	BU ACR % MN	YLD SC ABS	MST ABS	EAR SZ ABS	BAR PLT ABS	PLT HT ABS	EAR HT ABS	SDG VGR ABS	EST CNT ABS	CLD TST ABS	CLD TST % MN
TOTAL SUM		1	65.1	103	5.6	23.2	5.4	87.2	76.8	30.3	6.5	37.9	75.0	93
		2	76.6	121	5.8	23.2	5.5	85.7	80.3	32.9	5.5	37.0	80.0	99
		LOCS	52	52	23	52	14	16	34	34	43	80	2	2
		DIFF	11.5	18	0.2	0.0	0.1	1.5	3.5	2.6	1.0	1.0	5.0	6
		PROB	.0009	.0009	.686	.878	.612	.651	.0048	.0068	.0009	.090*	.344	.344

YEAR	REGION	VAR #	DRP EAR ABS	TIL LER ABS	GDU SHD ABS	GDU SLK ABS	POL SC ABS	TAS BLS ABS	TAS SZ ABS	TEX EAR ABS	TST WT ABS	GRN QUL ABS	SCT GRN ABS	STA GRN ABS
TOTAL SUM		1	99.6	0.9	146.8	148.5	5.2	9.0	5.4	7.1	57.5	6.6	5.9	6.6
		2	99.7	4.7	148.9	152.1	5.7	9.0	5.3	6.1	56.9	6.9	6.6	6.5
		LOCS	33	21	72	58	19	1	31	12	52	42	18	39
		DIFF	0.2	3.8	2.1	3.6	0.5	0.0	0.2	1.0	0.6	0.3	0.6	0.1
		PROB	.308	.073*	.0009	.0009	.216		.567	.0048	.0029	.124	.119	.795

YEAR	REGION	VAR #	STK LDG ABS	KT LDG ABS	BKT STK ABS	LOM RST ABS	EAR MLD ABS	GLF SPT ABS	MLF BLT ABS	SLF BLT ABS	STW WLT ABS	ECB DPE ABS	ECB ILF ABS	ECB 2SC ABS
TOTAL SUM		1	97.7	95.9	98.9	7.0	7.6	2.5	5.0	7.0	7.0	100.0	3.9	6.0
		2	90.8	98.3	96.1	7.0	7.4	3.2	3.0	3.0	8.0	100.0	4.4	5.5
		LOCS	42	20	7	1	20	7	1	1	2	2	36	23
		DIFF	6.8	2.3	2.7	0.0	0.1	0.7	2.0	4.0	1.0	0.0	0.5	0.5
		PROB	.0019	.391	.150		.839	.035+			.0009	1.00	.036+	.448

* = 10% SIG

00072

TABLE 3B-continued

PAIRED INBRED COMPARISON DATA
VARIETY #1 - PHP38
VARIETY #2 - PHO29

+ = 5% SIG
@ = 1% SIG

TABLE 4

PHP38 HYBRID COMPARED TO PIONEER HYBRID 3362
VARIETY #1 - PHP38 HYBRID
VARIETY #2 - 3362

YEAR	REGION	VAR #	PRM	SEL IND	BU ACR ABS	BU ACR % MN	MST ABS	GDU SHD ABS	STK LDG ABS	KT LDG ABS	BAR PLT ABS
TOTAL SUM		1	119	114	152.7	110	21.2	136.7	94.5	94.8	97.6
		2	118	105	144.7	104	20.9	137.2	92.8	95.3	98.5
		LOCS	15	15	75	75	75	23	66	40	21
		DIFF	1	9	8.0	6	0.3	0.5	1.7	0.5	0.8
		PROB	.160	.0009	.0009	.0009	.030+	.343	.011+	.490	.158

YEAR	REGION	VAR #	STA GRN ABS	TST WTA ABS	COB SC ABS	GRN QUL ABS	SDG VGR ABS	EST CNT ABS	PLT HT ABS	EAR HR ABS	DRP EAR ABS	BKT STK ABS
TOTAL SUM		1	6.2	58.4	4.8	7.5	6.2	61.4	104.7	43.9	99.4	98.3
		2	5.6	57.2	4.5	6.7	5.4	60.8	105.4	45.8	99.5	98.9
		LOCS	39	74	6	29	42	45	31	31	48	8
		DIFF	0.6	1.3	0.3	0.8	0.9	0.6	0.7	1.9	0.1	0.6
		PROB	.027+	.0009	.745	.0019	.0009	.435	.250	.014+	.741	.165

* = 10% SIG
+ = 5% SIG
@ = 1% SIG

TABLE 5

PHP38 HYBRID COMPARED TO PIONEER HYBRID 3467
VARIETY #1 - PHP38 HYBRID
VARIETY #2 - 3467

YEAR	REGION	VAR #	PRM	SEL IND	BU ACR ABS	BU ACR % MN	MST ABS	GDU SHD ABS	STK LDG ABS	KT LDG ABS
TOTAL SUM		1	117	91	116.5	86	16.6	130.3	92.2	92.8
		2	118	95	129.6	97	17.1	130.0	85.7	91.0
		LOCS	1	1	6	6	6	2	5	3
		DIFF	1	4	13.1	10	0.5	0.3	6.5	1.8
		PROB			.239	.203	.325	.874	.242	.707

YEAR	REGION	VAR #	BAR PLT ABS	STA GRN ABS	TST WTA ABS	GRN QUL ABS	SDG VGR ABS	EST CNT ABS	PLT HT ABS	EAR HT ABS	DRP EAR ABS
TOTAL SUM		1	96.7	4.8	59.1	5.8	5.8	44.1	109.5	48.3	99.6
		2	96.8	3.0	59.8	5.8	4.3	36.4	107.0	43.0	99.0
		LOCS	1	2	6	6	2	4	2	2	5
		DIFF	0.1	1.8	0.6	0.0	0.5	12.3	2.5	5.3	0.6
		PROB		.395	.260	.000	.500	.189	.344	.050+	.309

* = 10% SIG
+ = 5% SIG
@ = 1% SIG

00073

TABLE 6

PHP38 HYBRID COMPARED TO PIONEER HYBRID 3540
VARIETY #1 - PHP38 HYBRID
VARIETY #2 - 3540

YEAR	REGION	VAR #	PRM	SEL IND	BU ACR ABS	BU ACR % MN	MST ABS	GDU SHD ABS	STK LDG ABS	RT LDG ABS	BAR PLT ABS
TOTAL SUM		1	110	97	123.1	94	19.2	140.1	93.4	94.0	92.0
		2	110	94	120.2	93	19.3	142.4	93.1	97.0	87.5
		LOCS	8	8	38	38	43	13	39	10	2
		DIFF	0	3	2.9	1	0.1	2.2	0.3	3.0	4.5
		PROB	.848	.221	.156	.362	.536	.048+	.848	.332	.295

YEAR	REGION	VAR #	STA GRN ABS	TST WTA ABS	COB SC ABS	GRN QUL ABS	SDG VGR ABS	EST CNT ABS	PLT HT ABS	EAR HT ABS	DRP EAR ABS
TOTAL SUM		1	5.0	58.6	7.2	7.5	6.3	53.0	86.0	39.6	98.9
		2	5.4	57.7	7.2	7.0	6.1	52.1	88.0	40.2	99.6
		LOCS	27	39	3	39	34	33	21	21	36
		DIFF	0.4	0.8	0.0	0.4	0.2	0.9	2.1	0.7	0.7
		PROB	.062*	.000#	.000	.038+	.553	.311	.014+	.241	.041+

* = 10% SIG
+ = 5% SIG
# = 1% SIG

TABLE 7

PHP38 HYBRID COMPARED TO PIONEER HYBRID 3569
VARIETY #1 - PHP38 HYBRID
VARIETY #2 - 3569

YEAR	REGION	VAR #	PRM	SEL IND	BU ACR ABS	BU ACR % MN	MST ABS	GDU SHD ABS	STK LDG ABS	RT LDG ABS	BAR PLT ABS
TOTAL SUM		1	109	102	137.9	99	18.8	139.3	95.0	95.0	91.0
		2	108	99	136.0	99	18.5	140.0	85.4	98.0	92.7
		LOCS	12	12	52	52	55	15	50	17	9
		DIFF	1	3	1.9	1	0.3	0.6	9.6	3.0	1.6
		PROB	.114	.366	.404	.748	.224+	.346	.000#	.201	.259

YEAR	REGION	VAR #	STA GRN ABS	TST WTA ABS	COB SC ABS	GRN QUL ABS	SDG VGR ABS	EST CNT ABS	PLT HT ABS	EAR HT ABS	DRP EAR ABS
TOTAL SUM		1	4.9	58.9	7.1	7.5	6.7	59.5	91.8	42.2	98.7
		2	3.2	57.3	6.9	6.7	6.9	61.9	91.7	42.3	99.4
		LOCS	26	52	4	31	21	36	25	25	41
		DIFF	1.7	1.7	0.3	0.8	0.2	2.4	0.1	0.2	0.7
		PROB	.000#	.000#	.391	.008#	.455	.016+	.861	.825	.035+

* = 10% SIG
+ = 5% SIG
# = 1% SIG

TABLE 8

PHP38 HYBRID COMPARED TO PIONEER HYBRID 3379
VARIETY #1 - PHP38 HYBRID
VARIETY #2 - 3379

YEAR	REGION	VAR #	PRM	SEL IND	BU ACR ABS	BU ACR % MN	MST ABS	GDU SHD ABS	STK LDG ABS	RT LDG ABS	BAR PLT ABS
TOTAL SUM		1	124	102	140.5	99	21.0	142.3	98.2	94.8	94.1
		2	121	110	148.3	106	19.5	141.7	94.7	94.4	94.5
		LOCS	12	12	58	58	58	12	53	32	16
		DIFF	3	8	7.8	7	1.5	0.6	3.4	0.4	0.4

00074

TABLE 8-continued

PHP38 HYBRID COMPARED TO PIONEER HYBRID 3379
VARIETY #1 - PHP38 HYBRID
VARIETY #2 - 3379

YEAR	REGION	VAR #	STA GRN ABS	TST WTA ABS	COB SC ABS	GRN QUL ABS	SDG VGR ABS	EST CNT ABS	PLT HT ABS	EAR HT ABS	DRP EAR ABS	RRT STK ABS
		PROB	.006#	.057*	.004#	.004#	.000#	.395	.013+	.437	.556	
TOTAL SUM		1	6.7	58.0	6.9	7.9	6.2	60.7	99.5	42.9	99.7	95.5
		2	6.1	57.8	7.5	7.8	5.6	64.0	102.3	43.5	99.6	95.3
		LOCS	34	58	4	25	24	40	27	27	32	6
		DIFF	0.5	0.3	0.5	0.1	0.5	3.4	2.8	0.6	0.0	0.1
		PROB	.057*	.035+	.435	.648	.049+	.000#	.000#	.331	.773	.874

* = 10% SIG
+ = 5% SIG
# = 1% SIG

TABLE 9

PHP38 HYBRID COMPARED TO PIONEER HYBRID 3344
VARIETY #1 - PHP38 HYBRID
VARIETY #2 - 3344

YEAR	REGION	VAR #	PRM	SEL IND	BU ACR ABS	BU ACR % MN	MST ABS	GDU SHD ABS	STK LDG ABS	RT LDG ABS	BAR PLT ABS
TOTAL SUM		1	123	106	145.3	104	20.8	145.5	96.0	92.1	91.5
		2	122	106	144.7	104	20.6	144.9	91.2	93.3	94.5
		LOCS	13	14	77	77	77	16	75	30	13
		DIFF	1	1	0.6	0	0.2	0.6	4.8	1.2	3.0
		PROB	.140	.728	.758	.786	.156	.273	.000#	.497	.260

YEAR	REGION	VAR #	STA GRN ABS	TST WTA ABS	COB SC ABS	GRN QUL ABS	SDG VGR ABS	EST CNT ABS	PLT HT ABS	EAR HT ABS	DRP EAR ABS
TOTAL SUM		1	5.8	57.2	5.4	6.9	6.6	61.5	100.4	42.3	99.0
		2	5.1	55.8	5.8	6.2	5.7	62.0	100.3	42.1	99.8
		LOCS	43	77	6	42	26	47	29	29	38
		DIFF	0.7	1.4	0.4	0.7	0.8	0.5	0.1	0.2	0.7
		PROB	.000#	.000#	.238	.004#	.002#	.345	.878	.000	.007#

* = 10% SIG
+ = 5% SIG
# = 1% SIG

Deposits

Applicants have made available to the public without restriction a deposit of at least 2500 seeds of inbred PHP38 with the American Type Culture Collection (ATCC), Rockville, Md. 20852 U.S.A., ATCC Deposit No. 75612. The seeds were deposited with the ATCC on Nov. 9, 1993, and are taken from the same deposit maintained by Pioneer Hi-Bred International Inc., 700 Capital Square, 400 Locust Street, Des Moines, Iowa 50309 since prior to the filing date of this application. This deposit of the Inbred Corn Line PHP38 will be maintained without restriction in the ATCC depository, which is a public depository, for a period of 30 years, or 5 years after the most recent request, or for the effective life of the parent, whichever is longer, and will be replaced if it becomes nonviable during that period.

What is claimed is:

1. Inbred corn seed designated PHP38, having ATCC accession No. 75612.

2. A corn plant produced by the seed of claim 1.

3. A tissue culture of regenerable cells of the plant of claim 2.

4. Tissue culture according to claim 3 comprising regenerable cells of a plant part selected from meristematic tissue, anthers, leaves, embryos, pollen, and protoplasts thereof.

5. A corn plant regenerated from the regenerable cells of a tissue culture of claim 4, said plant possessing all the physiological and morphological characteristics of the inbred corn plant designated PHP38.

6. An inbred corn plant having all the physiological and morphological characteristics of the plant of claim 2.

* * * * *

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Tag/Label of Pioneer Hybrid Corn Seed Variety

PIONEER.
BRAND · SEED CORN

HYBRID: 34R06 KIND: FIELD CORN
LOT NO: C92HAL SIZE: PDR
ORIGIN: MI
GERM : 95% TESTED: DEC 1997
KERNELS/BAG: 80,000 92
CRM: 109 DAY

FERTILE CYTOPLASM

Pure Seed:	99.50%	Weed Seed:	None
Inert Matter:	0.50%	Other Crop Seed:	None
Noxious Weed Per Pound:			None

CAUTION: MAXIM®* (FLUDIOXONIL) & APRON®* (METALAXYL) TREATED
Do not use for food, feed or oil purposes. TREATED AT THE MANUFACTURERS' RECOMMENDED RATE. Keep out of reach of children.
DO NOT GRAZE UNTIL 30 DAYS AFTER PLANTING
*Trademarks of Ciba-Geigy Corporation.

HAZARD COMMUNICATION DATA

TREATED SEED CORN — CAUTION

Causes eye irritation. May cause skin irritation. Avoid contact with eyes, skin, or clothing. Harmful if inhaled or absorbed through the skin. Wash thoroughly with soap and water after handling. Remove contaminated clothing and wash before reuse. If contact occurs, flush eyes with plenty of water for at least 15 minutes. Seek medical attention if eye or skin irritation persists. Seek prompt medical attention if swallowed. Note to physician: If ingested, induce emesis or lavage stomach. Treat symptomatically. For more information call Pioneer at 1-800-247-6803, extension 4166.

THE FOLLOWING PROVISIONS ARE PART OF THE TERMS OF PURCHASE OF THIS PRODUCT

Pioneer Hi-Bred International, Inc., (Pioneer) warrants that the seed purchased from it conforms to the descriptions on the label within tolerances, if any, established by law. THIS EXPRESS WARRANTY EXCLUDES ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY AND OF FITNESS FOR A PARTICULAR PURPOSE. Buyer's sole remedy shall be limited to the purchase price of the seed. Buyer agrees to these terms (and the more fully described limitation of warranty and rem provisions on the bag) as a binding part of the purchase terms.

Pioneer sales representatives (agents) have no ownership interest in the PIONEER® brand products which they distribute. Consequently, a sales representative has no ability to grant a security interest in these products to his or her creditors.

UNAUTHORIZED EXPORT IS PROHIBITED.

This hybrid is produced and licensed under one or more of the following issued U.S. patents:

4731499	5097083	5220114	5349119	5435564	5491295	5527986
4806652	5097094	5245125	5354941	5436390	5491387	5530180
4806649	5097095	5276265	5354942	5444178	5495065	5530184
4812599	5097096	5285004	5363014	5463173	5495066	5602317
4812600	5157206	5304719	5367109	5476999	5495069	5608138
5082991	5157208	5304720	5387754	5491286	5502272	5608140
5082992	5159132	5347079	5387755	5491289	5506367	5618987
5095174	5159133	5347080	5416254	5491290	5506368	5639946
5097092	5159134	5347081	5434346	and/or other patents pending.		

License is granted solely to produce grain and/or forage. For other licenses, contact Pioneer Hi-Bred International, Inc.

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524-489-022964
Sold by: PIONEER HI-BRED INTERNATIONAL, INC.
SUPPLY MANAGEMENT • 6800 N.W. 62ND AVE. • P.O. Box 256 • JOHNSTON, IOWA 50131, U.S.A.

The purchase of these seeds includes a limited license under patent(s) US 5,500,365, US 5,352,605, US 5,759,142, US 5,322,938, US 5,164,316, US 5,196,525, US 5,424,412, US 5,424,200 (pending patent applications) to produce a single corn crop in the United States (or other applicable country). This license does not extend to the use of seed from such crop or the progeny thereof for propagation or seed multiplication. Furthermore, the use of such seed or the progeny thereof for propagation or seed multiplication or for production or development of a hybrid or different variety of seed is strictly prohibited.

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U.S. Patent No. 2,048,056

July 21, 1936. E. BOEHM 2,048,056

METHOD AND PRODUCT OF HYBRIDIZING PLANTS

Filed March 18, 1935

Fig. 1

Fig. 2

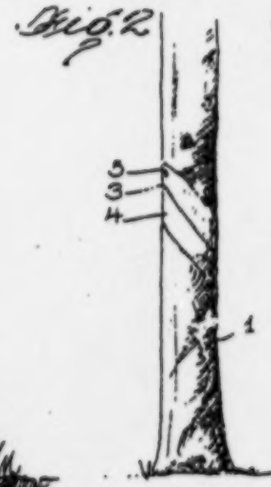

Fig. 3

Fig. 4

Fig. 5

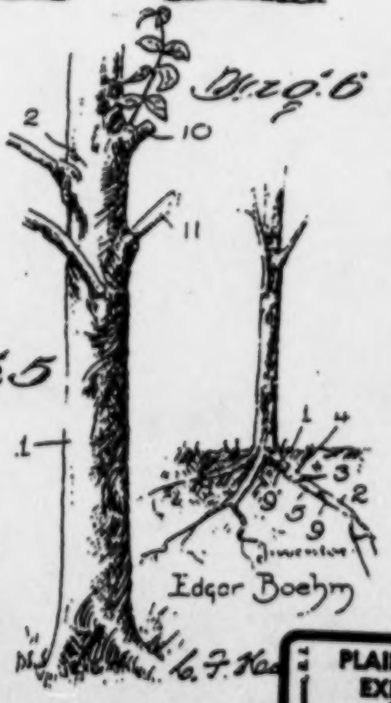

Fig. 6

Inventor
Edgar Boehm

6. F. Ke

PLAINTIFF'S EXHIBIT D

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Patented July 21, 1936

2,048,056

UNITED STATES PATENT OFFICE

2,048,056

METHOD AND PRODUCT OF HYBRIDIZING PLANTS

Edgar Boehm, Monette, Ark.

Application March 18, 1935, Serial No. 11,738

6 Claims. (Cl. 47—6)

This invention relates to a new and improved method and product of hybridizing plants. It was developed in producing new varieties of fruits, but it can be practised on any plant growth which can be successfully grafted either in the growth above ground or in the roots, and it is my intention to claim it in its broadest sense. In this specification I describe the hybridization of fruit trees and fruit bushes merely as illustrative; but I do not wish to be restricted to such use because the process may be used in developing hybrid flowers in those bushes which can be grafted in any well-known way.

When the pollen of the flower of one plant is deposited upon the pistil of the flower of another plant, both plants being of the same genus but of different species of that genus, cross-fertilization frequently occurs, and the plant which grows from the seed thus fertilized will be a hybrid, partaking of the characteristics of both of the parents but not exactly like either of them.

In the usual method of hybridizing, the pollen of a flower of one species is transferred to and placed upon the pistil of a flower of a different species, both flowers being of the same genus. To do this successfully it is necessary to remove the stamens of the flower to be cross-fertilized, before they discharge any of their pollen. Then pollen from a flower of a different species of the same genus is brought to and placed upon the pistil which remains in the flower which is to be cross-fertilized.

There are many objections and disadvantages in trying to hybridize by this well known method. In the very beginning, some pollen may be shaken off, when cutting out the stamens, and drop upon the pistil of the same flower. In such a case, all further operations are useless and merely a waste of time, because the flower will thus be fertilized by its own pollen and no hybridization results.

Then, too, both flowers must be in exactly the same state of maturity; that is, the pollen of one flower must be in the proper condition to fertilize, and the pistil of the other flower must be in the proper condition to be fertilized. If either flower is not in the proper condition, cross-fertilizing will not take place. As the flowers of different species of the same genus do not always mature at exactly the same time, it happens that some of the crosses that, theoretically, appear to be most desirable hybridizations cannot be made by cross-pollenization.

Another, probably the greatest disadvantage is: at best, cross-pollenization can be practiced only during the very brief period of time, when the flowers of both species are in bloom, a period so brief in some it is a matter of only a few hours.

Then, too, it is necessary to wait for years for the seed to grow and the plant to mature and bear fruit before the result of the hybridization can be known, or whether there has been any hybridization at all.

I have invented a process of hybridization which overcomes all these objections and disadvantages and frequently produces hybrid fruit the same growing season my hybridization process has been employed.

The principal object and the principal advantage in employing my process is to be able to practice hybridizing leisurely, at any time during the entire year when budding and ordinary grafting may be successfully done on similar plants.

Another important object is to know positively that hybridization has taken place as soon as the plant begins to grow, without having to wait for the planting of the seed, the growing of the plant, the maturing of the plant and its fruiting, before it can be determined if hybridization has occurred.

Another object which is peculiar to and is exclusively derived from my method, only, is: the ability to control, in a great degree, the result of the hybridization to resemble one parent plant more than the other or to have it partake of the nature of both parent plants approximately equally.

Other objects and advantages will appear as the description of my process proceeds.

To illustrate the best way I have devised to practice my invention I have filed the accompanying sheet of drawings which is made a part of this specification, and in which

Figure 1 illustrates an ordinary graft of the style usually called a splice graft, the wax and the wrapping commonly used being omitted;

Fig. 2 shows how the graft of Fig. 1 looks after a period of growth;

Fig. 3 shows the scion cut off above the area of mixed protoplasmic growth and twigs growing from the area affected by the grafting;

Fig. 4 shows how bud sports originate;

Fig. 5 shows how the whole growing power of the tree may be directed to one or more auxiliary buds; and

Fig. 6 shows how my method can be applied to berry bushes or other pithy stalked growths.

My method is not dependent upon the style of grafting used. I have shown splice grafting merely as illustrative, but whip grafting, tongue grafting, cleft grafting, crown grafting, side grafting, or any other style of grafting will do and it may be practiced by budding and by root grafting.

As it is desirable to be able to determine, easily, the approximate area of the bark of the stock and the bark of the scion, contiguous to the point of union of the two parts of the graft, which has been modified by the growth after grafting, I prefer to use splice grafting, saddle grafting,

tongue grafting, or whip grafting, merely because I seem to be better able to locate the limits of the modified area when I use grafting of these types; however, the style of grafting preferred is immaterial to the success of the method and is determined almost wholly by the size and the condition of the stock and scion and the whim of the operator.

In the several views of the drawing and in the detailed specification wherever an element is designated by a reference character the particular character used will be found always applied to that element and to no other.

The stock is designated by 1, the scion by 2, and the line of union between these parts by 3. Whenever a graft makes a satisfactory growth, there is, after such period of growth, an area above and below the union, easily determinable, in which the nature of the protoplasm of growth is modified by the mixture of the sap of both the stock and the scion. This area of mixed protoplasmic effect is designated by 4 and 5 respectively, in Figs. 2 and 6. The power of the sap of the stock and the power of the sap of the scion to influence the hybridizing character of the growth near the union produced by grafting decrease as the distance from the line of union of the two parts increases. The protoplasm is approximately equally potent and mixed at the line of union of the stock and the scion.

After the complete union of the stock and the scion, sprouts from adventitious buds usually spring out of the area of mixed protoplasmic influence. However, to insure that sprouts do spring from the area of mixed protoplasmic growth, I cut off the scion just above the area modified by the mixture of the sap from the two parts, as indicated in Fig. 3, and to prevent bleeding of the severed tree, it is desirable to cover the stump with some water-proof material, such as grafting wax, paint, asphaltum, tar or the like.

Soon after the scion is cut off as indicated at 9, sprouts 6, 7, and 8 spring out from the area of mixed protoplasmic influence, because of the excess of sap checked in its upward flow by the waterproof material adhering to the cut surface of the stump.

Usually a greater number of twigs start growing from the area of mixed protoplasmic influence than should be permitted to remain, and, after selecting the twigs to be developed into the crown of the tree, all the others should be pruned off.

The horticulturist should excerise his own judgment as to the character of the fruit desired from the bearing tree; but I find it more interesting and prefer to preserve some limbs 6, which take out below the line of union, some limbs 7, which grow exactly over the line of union and some limbs 8, which grow out above the line of union. Such selected limbs should be spaced circumferentially about the trunk to insure a properly balanced crown to the tree.

The fruit borne by limbs 8 will partake more of the nature of the fruit borne by the limbs of the stock growing entirely below the area of influence of the mixed protoplasm; the fruit borne by limbs 7 will partake equally of the natures of the stock and the scion; and the fruit borne by limbs 8 will partake more of the character and nature of the scion.

Should it be thought desirable to have fruit from the scion uninfluenced by the characteristics of the stock, all it is necessary to do is to make the cut 9 above the area influenced by the mixed protoplasm of the section contiguous the graft and permit branches to grow from the scion above the area so influenced by the mixed protoplasm.

Thus it is possible to have five varieties of fruit produced by a single grafting operation.

Assuming that an apple stock and a pear scion are used, the five different varieties of fruit from one tree the result of a single grafting operation will be as follows: First, the unmodified apple of the stock; second, the hybrid fruit in which the apple predominates, borne by limbs 6; third, the hybrid fruit in which the characteristics of the apple of the stock and the pear of the scion are approximately equal, borne by limbs 7; fourth, the hybrid fruit in which the pear nature predominates, borne by limbs 8; and fifth, the fruit of the pear scion which is uninfluenced by the apple characteristics, borne by limbs which grow out of the scion above the area modified by the mixed protoplasm of the scion and the stock.

Axillary buds 13 and adventitious buds 12 may be forced to grow by removing the bark from branches growing near them in the area of mixed protoplasm as shown at 10 and 11, see Fig. 5.

The growth of branches springing from adventitious buds 12 and axillary buds 13 is greatly augmented by killing undesirable limbs by girdling them or by stripping the bark therefrom or the same increased growth may be secured by removing such limbs bodily and waterproofing the wounds made by such pruning.

In practicing my method upon blackberry bushes, raspberry bushes, and the like, the roots should be operated upon; because it is almost impossible to graft the tops. Fig. 6 illustrates the mode of operation upon such bushes, which have large soft pithy growth tops, not suitable for grafting. In this figure 1 indicates the root stock or growing plant, 2 a root scion, 3 the line of union, 4 and 5 the area of mixed protoplasmic growth, 9' indicates where the scion should be severed and 9'' shows where the united graft should be cut from the growing plant. Usually, during the time the root graft is making a proper union, numerous buds or sprouts appear upon the uniting roots; but if they do not or if they do not appear at places desired, I cut out the graft on the lines 9 and 9'' and plant the piece of united root in a hot-bed or other suitable place for forcing. After a short time, buds and sprouts appear throughout the whole length of the planted root. I then take up the root and separate it into parts having one or more sprouts on each part and then plant the parts which will produce numerous plants each of which is a hybrid of the two plants used in the root-grafting process.

Having fully explained my invention and the best way to practice it, what I claim is:

1. The method of hybridizing plants which consists in grafting a scion to a stock whereby there is produced in the vicinity of the line of union between the stock and the scion an area of growth wherein the protoplasm of the stock and the protoplasm of the scion are mixed and then preventing the growth of limbs from any other area than that influenced by the said mixture of protoplasm.

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2. The method of hybridizing plants which consists of inserting a bud-scion into a stock and then limiting future growth of the stock to branches springing from the immediate vicinity of the union of the bud-scion and the stock where the protoplasm of the new growth is derived from both the bud-scion and the stock, by gradually pruning away all other growth.

3. The method of hybridizing the apple and the pear which consists of grafting a scion of one of them to a stock of the other one of them and then preventing the growth of limbs from all other parts of the grafted tree excepting that area about the union of the stock and the scion wherein the newly formed protoplasms of the growing apple wood and the growing pear wood are mixed.

4. The method of hybridizing plants having pithy stems which consists in grafting a root-scion of one plant to the root-stock of a growing plant, removing the grafted section of the root-graft and planting it, then after sprouts have appeared upon the planted root-graft, severing such root-graft into portions each of which has one or more sprouts, and then planting the several portions whereby hybridized plants are produced.

5. The plant which is the product of the method of claim 1, characterized by varietal qualities differing from those of either the stock or the scion in a degree corresponding to the distance of origin of said limbs from the point of union of the stock and the scion.

6. The plant which is the product of the method of claim 1, characterized by varietal qualities differing from those of either the stock or the scion, the characteristics of the stock or the scion predominating in the preserved limbs in a degree corresponding to the distance of their origin on the stock or on the scion, respectively, from the line of union between the stock and the scion.

EDGAR BOEHM.

U.S. Patent No. 4,143,486

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[45] **Mar. 13, 1979**

[54] **HYBRID WHEAT**

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[51] Int. Cl.[2] A01H 1/02

[52] U.S. Cl. 47/58; 47/DIG. 1

[58] Field of Search ..... 47/58, DIG. 1

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[57] ABSTRACT

Seeds of alloplasmic wheat, which contain at least one specific nuclear gene (Ms) and a cytoplasm which interacts with the specific nuclear gene (Ms) or genes (Ms Ms) to maintain the plant fertile, are treated by a mutagenic agent and, if necessary selfed to obtain seeds having embryos that contain only mutated nuclear genes (ms ms). The seeds having embryos without at least one specific nuclear gene (Ms), produce plants which are male sterile (A-line). The A-line plants are pollinated with pollen from euplasmic or alloplasmic wheat (B-line), having chromosomes including specific nuclear genes (Ms Ms), to produce hybrid wheat seeds. The available A-line seeds may be multiplied by crossing the A-line plants with B-line plants to produce A-line seeds. The B-line seeds are produced by pollinating A-line plants with pollen from plants (D-line) which contain cytoplasm that maintains fertility of the plants irrespective of presence or absence of specific nuclear gene (Ms) and which contain specific nuclear genes (Ms Ms). The pollen from plants grown from the resulting seeds is used to pollinate D-line plants. The resulting seeds are planted and the plants are self pollinated producing seeds which have embryos containing Ms Ms, Ms ms, or ms ms genes and cytoplasm that maintains fertility of the plants regardless of the presence of specific nuclear gene (Ms) or genes (Ms Ms). The seeds having embryos with ms ms genes are selected as the B-line seeds.

25 Claims, 3 Drawing Figures

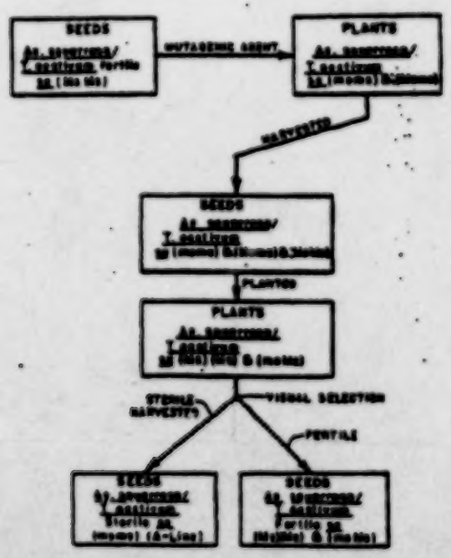

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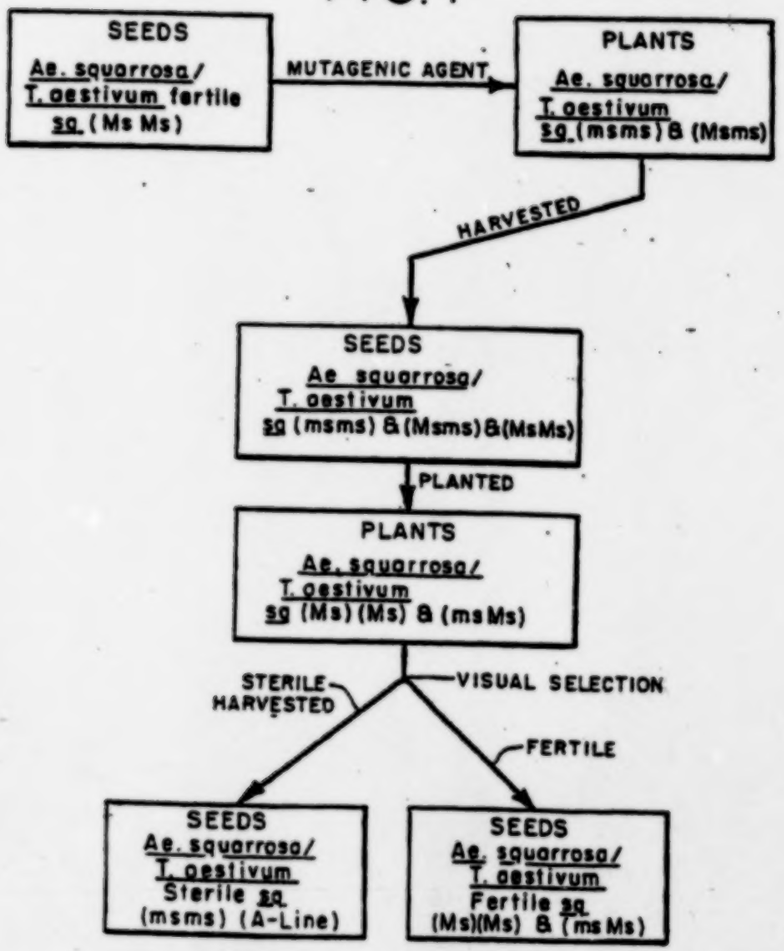
FIG. 1



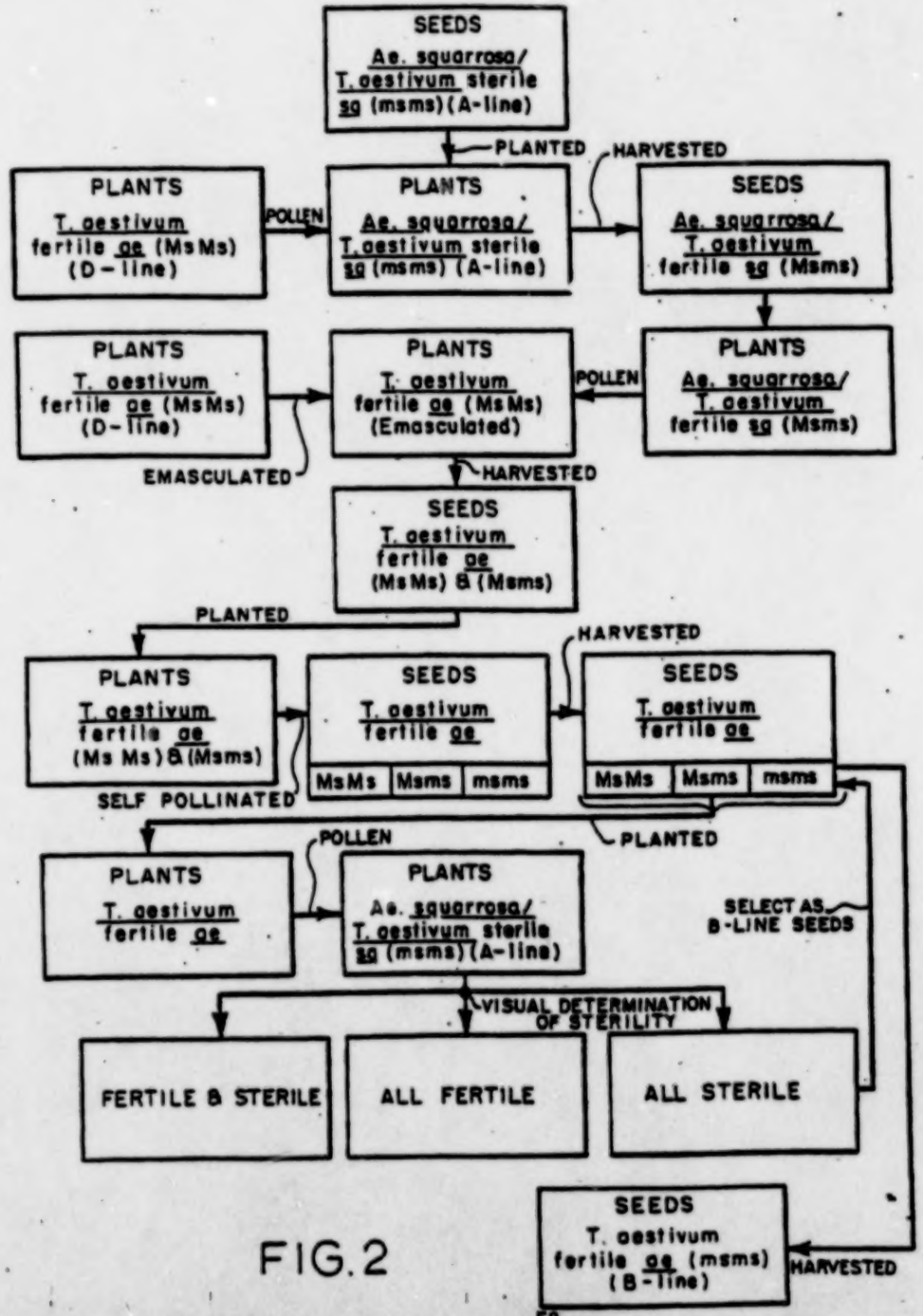


FIG. 2

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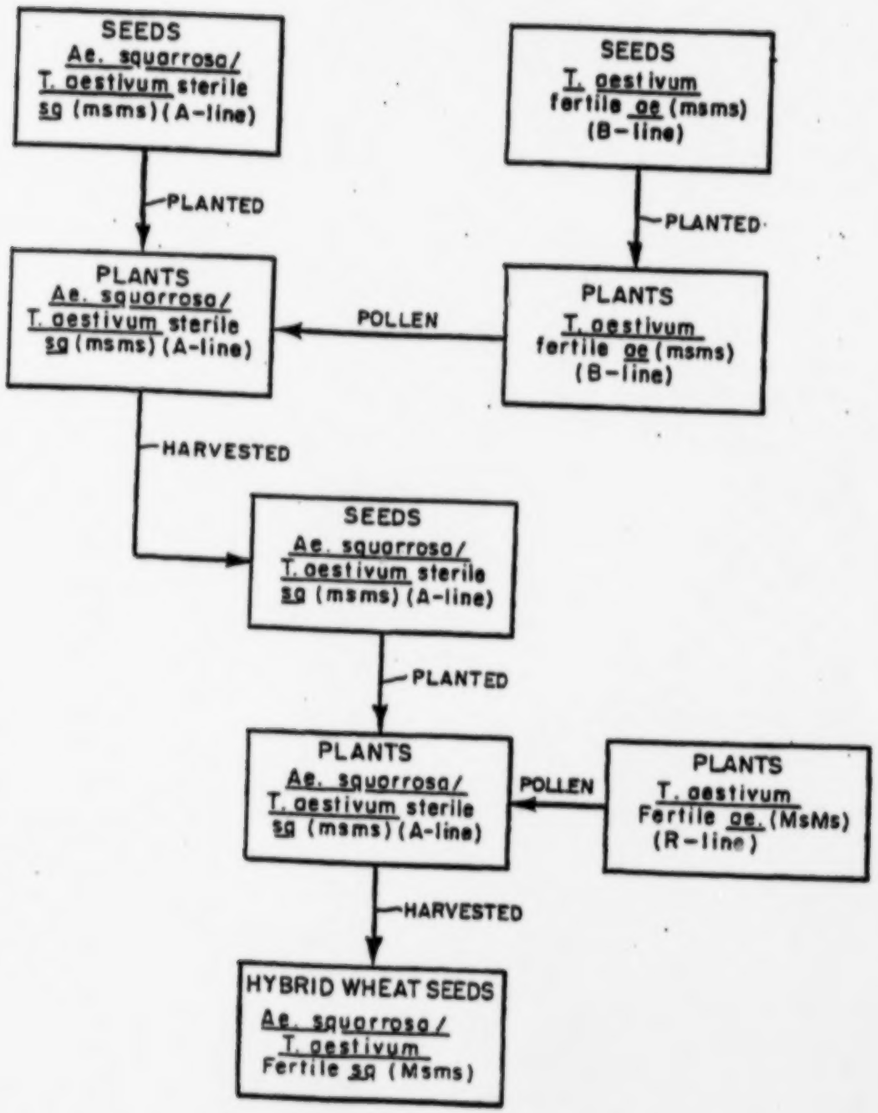
FIG. 3



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HYBRID WHEAT

BACKGROUND OF THE INVENTION

This invention relates to breeding of crop plants. In particular, it relates to producing hybrid wheat seeds on a commercial scale.

Controlled cross pollination of plants has been utilized by plant breeders for production of hybrid strains of plants which combine desirable qualities of the original parents. The desired first generation hybrid plants produced by controlled cross pollination have uniform qualities, including the size, height and genetic composition of plant products of economic importance. Since the progenies of the first generation hybrid plants have uneven physical characteristics and differ widely in genetic composition, in order to retain the advantages of a uniform, high quality hybrid crop, the farmer must be supplied with hybrid seeds each time he plants his crop.

One approach for controlling cross pollination of plants is to use cytoplasmic male sterility. In onion, for example, cytoplasmic male sterility can be introduced into one inbred line by backcrossing a fertile line which possesses some desired characteristics into plants that have cytoplasmic male sterility. The inbred male-sterile line is then planted in alternate stripe with a male fertile inbred line, in an isolated field. The cross pollination produces, on the male sterile plants, hybrid onion seeds for a commercial crop.

The cytoplasmic male sterility was also utilized in production of hybrid corn seeds as described in the U.S. Pat. No. 2,753,663. Unlike in onion where the vegetative plant parts are of economic value, in corn it is the seed that is harvested. Since male sterile corn plants produce no seeds, a hybrid produced in accordance with a method for production of onion hybrids would be useless to the farmer. The problem was solved by utilizing a fertility restoring plant for the final cross resulting in a hybrid corn seed.

The researchers have attempted to apply the method disclosed in U.S. Pat. No. 2,753,663 to wheat; however, despite continuing efforts, commercially satisfactory restorer plants have not been found. The development of a satisfactory hybrid wheat system has been complicated by the fact that the wheat flower is biexual and since in wheat the anthers are in the florets, the plants are practically always self pollinated. The location of the wheat anthers inside the florets and the fact that pollen is shed before flowers open makes introduction of male sterility in wheat by physical means (such as manual emasculation) commercially unfeasible. A genetic system, based on cytoplasmic sterility, appears to be the only feasible way for commercial production of hybrid wheat seeds.

The invention satisfies the long felt need for a relatively simple, commercially feasible method of producing hybrid wheat seeds.

Thus one object of the invention is to provide a genetic method for a production of hybrid wheat seeds.

Another object of the invention is to provide a commercially feasible and reliable method for production of hybrid wheat seedt.

A further object of the invention is to use cytoplasmic genetic sterility to produce hybrid wheat seeds having desirable properties.

Still another object of the invention is to provide a genetic method for producing hybrid wheat seeds, which does not require special development of the restorer line and in which conventional common wheat cultivars can be used as the restorer line.

Other objects of the invention will become apparent to those skilled in the art upon studying this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts a sequence of steps for the production of cytoplasmically male-sterile plants (A-line) to be used for the production of hybrid wheat in accordance with one embodiment of the method of this invention.

FIG. 2 depicts a sequence of steps for production of B-line plants which are used to multiply the available male sterile seeds (A-line) in accordance with one embodiment of this invention.

FIG. 3 depicts a sequence of steps for multiplying available A-line seeds and for producing hybrid wheat seeds in accordance with one embodiment of the present invention.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention, fertile alloplasmic wheat plants, in which fertility is maintained by at least one specific nuclear gene (Ms) interacting with the cytoplasm, are treated to induce mutations of the specific nuclear gene (Ms) or genes (Ms Ms). Those plants, in which all specific nuclear genes (Ms Ms) are changed by the treatment to mutated nuclear genes (ms ms) and which are therefore male sterile, are selected as A-line seeds. The embryos of seeds, which after treatment contain one mutated nuclear gene (ms) and one specific nuclear gene (Ms), are selfed and those of the resulting seeds that contain only mutated nuclear (ms ms) genes are selected as A-line seeds. The A-line seeds are planted and cross pollinated with a compatible wheat plant (R-line) having specific nuclear genes (Ms Ms) required for maintaining of fertility in the cytoplasm of A-line plants. The resulting hybrid wheat seeds have the cytoplasm of the A-line plants and at least one fertility maintaining specific nuclear gene (Ms).

In accordance with another aspect of the invention, the maintainer plants (B-line) are developed as follows. The A-line plants are cross pollinated with compatible wheat plants (D-line) having cytoplasm, which maintains the plant fertile regardless of the presence or absence of the specific nuclear gene (Ms) or genes (Ms Ms), and having chromosomes which have homozygous specific nuclear genes (Ms Ms). The pollen of the plants grown from the seeds produced by the cross pollination is used to pollinate D-line plants. The seeds produced on the D-line plants are grown and the plants are self pollinated. Some of the resulting seeds from each plant are planted and tested to determine which of the seeds have embryos containing only the mutated nuclear genes (ms ms). The seeds of the plants that are determined to have the mutated nuclear genes (ms ms) and no specific nuclear gene (Ms) or genes (Ms Ms) are selected as B-line seeds.

In accordance with a further aspect of the invention, there is provided a method for a commercial production of hybrid wheat seeds. The seeds of alloplasmic wheat, having cytoplasm that interacts with at least one specific nuclear gene (Ms) to maintain the fertility of the plant, are treated by a mutagenic agent to induce mutations of the specific nuclear genes (Ms Ms) into mutated nuclear genes (ms ms). The seeds, having embryos containing only mutated nuclear genes (ms ms) (i.e. no

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specific nuclear genes (Ms Ms)), are selected as A-line seeds, either directly or by selfing the plants containing one mutated nuclear gene (ms) and one specific nuclear gene (Ms) and selecting those resulting seeds that contain only mutated nuclear genes (ms ms). The A-line seeds are grown and the plants are pollinated by pollen from compatible wheat plants (D-line) having cytoplasm which remains fertile irrespective of the presence of specific nuclear gene (Ms) or genes (Ms Ms) and having chromosomes which include specific nuclear genes (Ms Ms) that are capable of maintaining fertility of the A-line cytoplasm. The resultant seeds are planted and the pollen therefrom is used to pollinate the D-line plants. The seeds produced on D-line plants are then grown and self pollinated (selfed). The seeds of the self pollinated plants, that contain only the mutated nuclear genes (ms ms) are then selected as B-line seeds. The B-line seeds are planted. The pollen from the B-line plants is used to pollinate A-line plants. The A-line plants pollinated by pollen from B-line plants produce seeds containing embryos which have genetic composition of A-line plants. Thus, the A-line seeds are quickly multiplied. The A-line seeds are grown and the plants are crossed with compatible wheat plants (R-line), that have chromosomes containing at least one specific nuclear gene (Ms), which maintains fertility of A-line cytoplasm, producing hybrid wheat seeds.

Other aspects of the invention will become apparent to those skilled in the art upon studying this specification and the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

The seeds of fertile alloplasmic wheat, in which fertility is maintained as the result of the interaction between at least one specific nuclear gene (Ms) and the cytoplasm, are treated to induce mutations of the specific nuclear genes (Ms Ms). As the result of the treatment, the specific nuclear genes (Ms Ms) become mutated nuclear genes (ms ms) which do not maintain fertility of the plants having the cytoplasm present in the alloplasmic wheat plant. Most seeds, in which mutation occurs, contain after treatment in their embryos one specific nuclear gene (Ms) and one mutated nuclear gene (ms). All seeds are planted and the plants are selfed. The resulting seeds include those that possess only mutated nuclear genes (ms ms) in their embryos. The seeds of those plants or their progeny that have only mutated nuclear genes (ms ms) and therefore exhibit cytoplasmic male sterility, are selected as A-line plants. The A-line plants are cross pollinated by pollen from compatible wheat plants (R-line) which have chromosomes that contain specific nuclear genes (Ms Ms) needed for maintaining the fertility in the A-line plants. The cross produces hybrid wheat seeds which have the cytoplasm of the A-line plants and have chromosomes that include at least one specific nuclear gene (Ms) necessary for maintaining the fertility of the hybrid plant.

In practice, only a small number of plants grown from the treated seeds exhibit cytoplasmic sterility (A-line). An additional phase, of extreme importance to the commercial production of hybrid wheat seeds, may be added to the method of this invention to produce maintainer plants (B-line) which when cross pollinated with the A-line plants produce seeds which have genetic composition of A-line plants. Since each A-line plant, when pollinated by the pollen of a B-line plant, produces a large number (250–500) of A-line seeds, the development and use of the B-line permits a rapid multiplication of the available A-line seeds. The A-line plants grown from seeds produced by pollen of B-line plants are used for the final cross to obtain hybrid wheat seeds.

The B-line is developed in accordance with this invention as follows. The A-line plants are cross pollinated with pollen of compatible wheat plants (D-line) having chromosomes which include specific nuclear genes (Ms Ms) which are capable of making plants having the A-line cytoplasm fertile and having cytoplasm that maintains fertility of the plants, regardless of the presence or absence of the specific genes (Ms Ms). The seeds, resulting from the cross, are planted and the pollen grown from these plants is used to cross pollinate D-line plants. The seeds obtained from the cross have fertile cytoplasm of D-line plants and contain either chromosomes having only fertility maintaining genes (Ms Ms) or having a specific nuclear gene (Ms) dominating a mutated gene (ms). The plants grown from these seeds are self pollinated. The seeds produced by self pollination have one of the following three types of embryos:

1. having only specific nuclear genes (Ms Ms);
2. having both a specific nuclear gene (Ms) and a mutated nuclear gene (ms); and
3. having only mutated nuclear genes (ms ms).

All three types of seeds contain D-line cytoplasm; therefore, all plants grown from these seeds are fertile. The B-line seeds are those that contain only mutated nuclear genes (ms ms). To determine which of the seeds are the B-line seeds, the seeds are planted and the pollen from each grown plant is used to pollinate a separate A-line plant. A record of which plant pollen is supplied to which A-line plant, is kept. The resulting seeds are harvested and planted. The plants are visually inspected to determine whether they are fertile or sterile. The seeds of plants, which supplied pollen that produced all sterile progeny when crossed with A-line plants, are selected as B-line seeds.

The B-line plants are then grown from the B-line seeds and crossed with A-line plants. The resulting seeds have a genetic composition of A-line plants. The step of crossing B-line plants with A-line plants can be repeated as often as needed to obtain the desired number of A-line seeds. The seeds of A-line plants are then planted and crossed with R-line plants to produce hybrid wheat seeds.

Throughout this disclosure, the term "alloplasmic wheat" shall mean wheat that has nucleus of wheat and an alien cytoplasm, i.e., cytoplasm which is different from that of common wheat. The term "euplasmic wheat" shall mean wheat plant having wheat cytoplasm and wheat nucleus. The term "compatible wheat plants" shall mean wheat plants that can be cross pollinated to produce seeds.

Two types of seeds are required to initiate the production of hybrid wheat seeds in accordance with this invention:

1. seeds that upon treatment with mutagenic agent become A-line seeds (predecessor of A-line) and,
2. R-line seeds.

The predecessor of A-line seeds are alloplasmic wheat seeds having a cytoplasm that interacts with at least one specific nuclear gene (Ms) to make the plant fertile. The R-line seeds are wheat seeds which contain the specific nuclear genes (Ms Ms) and which are genetically compatible with the A-line plants.

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If the method includes multiplication of A-line seeds, D-line seeds are also required. The D-line seeds have cytoplasm that remains fertile regardless of the presence or absence of the specific nuclear genes (Ms Ms) and have chromosomes that include the specific nuclear genes (Ms Ms) and no mutated genes (ms ms). It should be noted that D-line plants can also serve as R-line plants.

Alloplasmic wheat seeds, that are preferred as A-line predecessor, have Aegilops cytoplasm and *Triticum aestivum* nucleus. Especially preferred are the seeds of alloplasmic wheat plants having cytoplasm of the following Aegilops species: *Ae. squarrosa, Ae. cylindrica, Ae. ventricosa, Ae. crassa, Ae. juvenalis,* and *Ae. uniaristata.*

The preferred R-line seeds include euplasmic and alloplasmic *T. aestivum.* Especially preferred are the following plants: euplasmic *T. aestivum* and alloplasmic *T. aestivum* having cytoplasm and specific nuclear genes of *T. timopheevi, T. zhukovskyi, T. araraticum.*

Those skilled in the art can ascertain, with a minimum amount of experimentation, whether a given plant is suitable for the use in the given system for production of hybrid wheat seeds in accordance with the method of this invention and whether given wheat plants are compatible.

The treatment of predecessor A-line seeds can be accomplished by any method which produces point mutations on the chromosomes. For example, the seeds can be treated with mutagenic chemical substances, such as, diethyl sulphate, ethylene imine, ethyl methanesolfonate, and nitroso ethyl urea, or with ionizing radiation from sources, such as, X-rays, gamma rays and Co 60. The radiation having feqsency from about 10^{17} cycles/sec to about 10^{19} cycles/sec and intensity from about 10 rad/min to about 10,000 rad/min is preferred. The duration of the treatment varies depending on the specific type of the treatment but the duration should be long enough to induce point mutations on the chromosomes but should be terminated before inducing nonviability in seeds or seedlings treated. The preferred treatment with ethyl methanesulfonate lasts from about 12 to about 24 hours. The usual duration of the irradiation in the preferred range of frequency and intensity is from about 1 to about 50 hours.

The preferred method of producing hybrid wheat seeds can be subdivided into the following two phases:

1. production of the A-line;
2. production of the hybrid wheat seeds.

The following additional two phases are needed if multiplication of A-line seeds is employed to produce commercial quantities of hybrid wheat seeds.

3. production of the B-line;
4. multiplication of the A-line.

It is contemplated that in a commercial application, the A line and B line plants are produced first. Then the A-line seeds are multiplied and finally hybrid wheat seeds are produced by crossing A-line plants with the R-line plants. The preferred embodiment of the invention will now be described in reference to the drawings; the sequence of steps will be that of a commercial application.

Production of A-line

The seeds of alloplasmic *T. aestivum* having specific nuclear genes (Ms Ms), which maintain fertility of its *Ae. squarrosa* cytoplasm are soaked in a water solution of the mixture of an alkali metal salt of a strong acid and an alkali metal hydroxide, such as, potassium acid phosphate and sodium hydroxide, for a period of time sufficient to allow the solution to fully permeate the seeds. The relative amounts of the alkali metal salt and of the alkali metal hydroxide are such as to maintain the water solution of pH between 6 and 10 and preferably between 7.5 and 8.5. The concentration of alkali metal salt and of alkali metal hydroxide can vary considerably. The preferred range of concentration of alkali metal salt is from about 0.01M (M=molar) to about 0.1M and the preferred concentration of alkali metal hydroxide is from about 0.001M to about 0.05M. The specially preferred ranges of concentration of alkali metal salt and alkali metal hydroxide are from about 0.03M to about 0.07M and from about 0.005M to about 0.015M, respectively. The temperature of the presoaking can vary considerably, the preferred range being from about 50° F. (10° C.) to about 80° F. (27° C.).

The soaked seeds are contacted with a mutagen, such as, water solution of ethyl methane sulfonate (EMS) for a sufficient period of time at such conditions including concentration, pH and temperature as to induce point mutations in the chromosomes in the seeds. The usual ranges for the treatment are as follows: EMS concentration, in a buffer solution of the same composition as for presoaking, from about 0.05M to about 0.3M, pH range from about 6 to about 10, temperature from about 50° F. (10° C.) to about 80° F. (27° C.).

Some of the treated seeds become inviable or they produce sterile plants as the result of non-genetic effect (toxic) on seeds and seedlings. Such non-genetic sterility is generally not inheritable. Furthermore, statistically in most of the embryos of seeds that undergo mutation, only one specific nuclear gene is mutated. To assure that only those plants that contain only mutated nuclear genes (ms ms) are chosen as male-sterile A-line plants, the treated seeds are grown. All the seeds grown have embryos containing *Ae. squarrosa* cytoplasm and *T. aestivum* nucleus (as shown in FIG. 1). The seeds have one of the three combinations of genes: ms ms, Ms Ms, Ms ms. Statistically ms ms combination is unlikely to occur in the first generation of plants grown from the treated seeds, therefore, the assumption is made that all plants fall into the last two categories. As depicted in FIG. 1, all the seeds are planted and grown. The resulting plants are self pollinated (selfed) to produce seeds that include those having only mutated nuclear genes (ms ms). The seeds are harvested and planted in rows. Each row contains seeds from one plant. Some of the seeds from each plant are saved. To determine whether the plants are sterile or fertile, all plants are visually inspected at anthesis. The sterile plants have malformed anthers and their florets remain open longer than those of the fertile plants. Those rows that contain a large proportion of sterile plants come from seeds that have only mutated genes (ms ms). The remaining seeds from plants that produced sterile seeds are selected as A-line seeds. This is because, since the specific nuclear gene (Ms) is dominant with respect to mutated nuclear gene (ms), only plants having homozygous recessive nuclear genes (ms ms) exhibit genetic sterility. The remaining seeds of those plants are saved as additional source of A-line seeds.

Production of B-line

Referring now to FIG. 2, the A-line seeds are planted and the plants grown are crossed with *T. aestivum* plants (common wheat). The chromosomes of *T. ae-*

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tivum contain specific nuclear genes (Ms Ms) which can maintain or restore fertility of plants having *Ae. squarrosa* cytoplasm. The plants having *T. aestivum* cytoplasm remain fertile regardless of the presence or absence of the specific nuclear genes (Ms Ms). The seeds produced by the cross have *Ae. squarrosa* cytoplasm and *T. aestivum* chromosomes containing both a specific fertility maintaining or restoring gene (Ms) and a mutated nuclear gene (ms). Since the mutated nuclear gene (ms) is recessive, it is dominated by the fertility maintaining or restoring gene (Ms) and the plants grown from these seeds are male fertile. The male fertile plants are then crossed with *T. aestivum* (common wheat) plant, but this time the *T. aestivum* plant being the female parent. To prevent self pollination and to make the desired cross, the florets of the *T. aestivum* plants are manually emasculated, as by removing anthers with tweezers. All of the resulting plants from the cross have *T. aestivum* cytoplasm and chromosomes that either contain all specific nuclear gene (Ms) (homozygous) or one specific nuclear gene (Ms) gene and one mutated nuclear gene (ms) (heterozygous). The seeds of these plants are grown and the plants are selfed. The embryos of the resulting seeds have *T. aestivum* cytoplasm and any of the three combinations of genes: Ms ms, Ms Ms and ms ms. Since plants containing *T. aestivum* cytoplasm remain fertile irrespective of presence of specific nuclear gene (Ms), all seeds produce fertile plants.

To select the seeds that have embryos containing homozygous mutated nuclear genes (ms ms), the following procedure is followed. Some of the seeds from each plant are planted and grown. The pollen from each plant is used to pollinate a separate A-line plant or a separate spike on an A-line plant. A record of which A-line plant is pollinated by pollen from which plant, is kept. The resulting seeds are harvested and planted. The resulting plants are visually examined to determine whether they are sterile or fertile in accordance with the procedure discussed before (i.e. by examining their anthers and checking the time period during which florets remain open). The seeds of those plants, which produced functional pollen but which resulted in all male sterile progeny when crossed with male sterile A-line plants, are selected as B-line seeds.

Multiplication of the A-line

Referring now to FIG. 3, the B-line seeds are planted and these plants are crossed with the A-line plants. The B-line plants i.e., plants that have *T. aestivum* cytoplasm and chromosomes that include the mutated recessive genes (ms ms) and no specific nuclear gene (Ms) produce seeds in A-line plants which have a genetic composition of A-line plants. Since each A-line plant generally produces from about 250 to about 500 seeds, the number of available A-line seeds is quickly multiplied.

Production of Hybrid Wheat Seeds

As illustrated in FIG. 3, the A-line seeds are then planted and cross pollinated with the pollen from *T. aestivum* (euplasmic) plants (common wheat). The euplasmic *T. aestivum* plants (R-line) have *T. aestivum* cytoplasm and *T. aestivum* nucleus which contains specific nuclear genes (Ms Ms) which are capable of maintaining or restoring fertility of plants having *Ae. squarrosa* cytoplasm. The resulting hybrid wheat seeds have *Ae. squarrosa* cytoplasm and *T. aestivum* nucleus which includes one specific nuclear gene (Ms) and one mutated nuclear gene (ms). Since the Ms gene is dominant over the ms gene, the plants grown from the hybrid wheat seeds are fertile.

The following example is intended to further illustrate the invention. It is not intended to restrict the scope of the claimed invention in any manner.

EXAMPLE

Two Phase Production of Hybrid Wheat Seeds

Five hundred seeds from plants having *Ae. squarrosa* cytoplasm and *T. aestivum* nucleus, were presoaked for 8 hours at a temperature of 21° C. in a water solution of potassium acid phosphate and sodium hydroxide adjusted to pH 8. The seeds were removed from the buffer solution and immersed in a solution comprising 0.35 volume percent of ethyl methanesulphate (EMS) and the rest buffer solution having the same composition as the presoaking solution. The EMS-buffer solution was adjusted to pH 8 and maintained at 21° C. during the treatment.

After 16 hours, the seeds were removed from the EMS-buffer solution and planted in a greenhouse. The spikes of the resultant plants were bagged and the plants were allowed to self pollinate. The 45,000 seeds obtained from self pollination were harvested and planted in the field. The seeds were planted about 3 to 4 inches apart within the rows, and space between the rows was about 2.5 to 3.0 feet. The plants were visually examined for anther abnormalities at the time when florets started opening, i.e., after 3 to 5 days after spike emergence from the topmost leaf sheet on the primary tiller of a plant. One or more spikes of plants having abnormal anthers were bagged to exclude the possibility of seed set resulting from cross pollination from the neighboring fertile plants. Those plants that had malformed anthers and had florets that remained opened, were considered completely or highly sterile. Completely or highly sterile plants were crossed with *T. aestivum* cultivars Chris. The resulting seeds from the crossed spikes from 39 of the 45,000 plants were harvested for evaluation as follows. The seeds from crosses of the 39 plants were planted in the greenhouse. The spikes of the plants were bagged to obtain selfed seeds. The selfed seeds were planted and grown in the field. The plants were visually examined for sterility in accordance with the technique described above. The seeds from plants that produced sterile plants were chosen as A-line seeds. The A-line seeds were planted in alternate rows with the seeds of *T. aestivum* cultivar Chris and the resulting plants were allowed to cross pollinate resulting in hybrid wheat seeds, which produced fertile plants when grown.

Many changes and modifications will occur to those skilled in the art upon studying this disclosure. All changes that are within the spirit of the invention are intended to be included within its scope as defined by the appended claims.

I claim:

1. A method for producing hybrid wheat seeds which comprises:
   (a) inducing mutation of a specific nuclear gene in embryos of seeds of alloplasmic wheat plants, having chromosomes of wheat and a cytoplasm which is maintained fertile as the result of interaction between it and at least one specific nuclear gene;
   (b) selfing plants grown from seeds of step "a" to produce seeds;

   (c) selecting from seeds produced in step "b" those that contain only mutated nuclear genes in their embryos and are therefore male sterile; and,
   (d) crossing plants grown from the seeds of step "c" with compatible wheat plants, having chromosomes containing specific nuclear genes capable of maintaining fertility of the cytoplasm of plants produced in step "c", to produce hybrid wheat seeds having cytoplasm of the alloplasmic wheat plant and embryo having at least one fertility maintaining specific nuclear gene dominating the mutated nuclear gene.

2. A method as claimed in claim 1 wherein the seeds of alloplasmic wheat have Aegilops cytoplasm and *Triticum aestivum* nucleus.

3. A product produced in accordance with the method of claim 2.

4. A method as claimed in claim 1 wherein the seeds of alloplasmic wheat are selected from the group consisting of *Ae. squarrosa/T. aestivum, Ae. cylindrica/T. aestivum, Ae. ventricosa/T. aestivum, Ae. crassa/T. aestivum, Ae. juvenalis/T. aestivum,* and *Ae. uniaristata/T. aestivum,* and the compatible wheat plant is selected from the group consisting of *T. aestivum, T. aestivum/T. timopheevi, T. aestivum/T. zhukovskyi,* and *T. aestivum/T. araraticum.*

5. A product produced in accordance with the method of claim 4.

6. A method as claimed in claim 1 wherein the seeds of step "a" are *Ae. squarrosa/T. aestivum* and the compatible wheat plant is *T. aestivum.*

7. A method as claimed in claim 6 wherein the mutations are induced by treatment with a mutagenic chemical.

8. A product produced in accordance with the method of claim 7.

9. A method as claimed in claim 6 wherein the mutations are induced by ionizing radiation.

10. A method as claimed in claim 6 wherein the step of inducing mutation comprises:
   soaking the seeds in a water solution of a mixture of an alkali metal salt of a strong acid and an alkali metal hydroxide for a sufficient period of time to allow water solution to fully permeate the seeds; and
   contacting the seeds removed from the water solution of the soaking step with ethyl methansulfonate for a sufficient period of time and at such conditions including temperature, pH and concentration as to induce said mutation, the contacting being terminated before said seeds become nonviable.

11. A method as claimed in claim 1 wherein the mutations are induced by treatment with a mutagenic chemical.

12. A method as claimed in claim 1 wherein the mutations are induced by ionizing radiation.

13. A product produced in accordance with the method of claim 1.

14. A method for producing seeds to be used for multiplying alloplasmic wheat A-line seeds having chromosomes of wheat containing only mutated specific genes and cytoplasm maintaining fertility of a plant only in the presence of at least one specific nuclear gene, said method comprising the following steps:
   (a) crossing the plants grown from said A-line seeds with compatible wheat plants having specific nuclear genes capable of maintaining fertility of the cytoplasm of the alloplasmic A-line wheat plant and cytoplasm that remains fertile regardless of the presence of a least one said specific nuclear gene;
   (b) pollinating said compatible wheat plants with pollen from plants grown from seeds of step "a";
   (c) selfing plants grown from seeds obtained in step "b" to obtain seeds including B-line seeds containing in their embryos fertile cytoplasm of the compatible wheat plants and only mutated specific genes, said B-line seeds when grown into plants and crossed with said A-line plants producing seeds having genetic composition of A-line plants;
   (d) selecting B-line seeds from seeds of step "c".

15. A method as claimed in claim 14 wherein A-line plants are *Ae. squarrosa/T. aestivum* and the compatible wheat plant is *T. aestivum.*

16. A product produced in accordance with the method of claim 14.

17. A method for producing male-sterile alloplasmic wheat seed which comprises the following steps:
   (a) inducing mutation of a specific nuclear gene in embryos of seeds of alloplasmic wheat plants, having chromosomes of wheat and a cytoplasm which is maintained fertile as the result of interaction between it and at least one specific nuclear gene;
   (b) selfing plants grown from seeds of step "a" to produce seeds; and,
   (c) selecting from seeds produced in step "b" those that contain only mutated nuclear genes in their embryos and are therefore male sterile.

18. A method as claimed in claim 17 wherein the seeds of alloplasmic wheat are selected from the group consisting of *Ae. squarrosa/T. aestivum, Ae. cylindrica/T. aestivum, Ae. ventricosa/T. aestivum, Ae. crassa/T. aestivum, Ae. juvenalis/T. aestivum,* and *Ae. uniaristata/T. aestivum,* and the compatible wheat plant is selected from the group consisting of *T. aestivum, T. aestivum/T. timopheevi, T. aestivum/T. zhukovskyi,* and *T. aestivum/T. araraticum.*

19. A method of claim 18 wherein said first compatible wheat plants are the same as said second compatible wheat plants.

20. A method as claimed in claim 19 wherein the seeds of alloplasmic wheat are selected from the group consisting of *Ae. squarrosa/T. aestivum, Ae. cylindrica/T. aestivum, Ae. ventricosa/T. aestivum, Ae. crassa/T. aestivum, Ae. juvenalis/T. aestivum,* and *Ae. uniaristata/T. aestivum,* and the compatible wheat plant is selected from the group consisting of *T. aestivum, T. aestivum/T. timopheevi, T. aestivum/T. zhukovskyi,* and *T. aestivum/T. araraticum.*

21. A product produced in accordance with the method of claim 17.

22. A method for producing hybrid wheat seeds which comprises the following steps:
   (a) inducing mutations of fertility maintaining nuclear genes into mutated nuclear genes in seeds of an alloplasmic wheat plant, having cytoplasm depending for its fertility on the interaction with at least one fertility maintaining nuclear genes;
   (b) selfing plants grown from said seeds to obtain seeds;
   (c) selecting seeds producing male fertile plants, said seeds having in their embryos only mutated nuclear genes;
   (d) crossing the plants grown from seeds of step "c" with a first compatible wheat plant having a cytoplasm remaining fertile regardless of the presence

of said specific nuclear genes and having chromosomes containing said specific nuclear genes;

(e) pollinating said first compatible wheat plant with the pollen from the plants grown from seeds of step "d";

(f) selfing plants grown from the seeds produced in step "e";

(g) selecting from seeds produced in step "f" those that contain only mutated nuclear genes;

(h) crossing plants grown from seeds selected in step "g" with plants grown from seeds of step "c";

(i) crossing plants grown from seeds produced in step "h" with a second compatible wheat plant having chromosomes containing said specific nuclear genes to produce seeds of a hybrid wheat plant.

23. A product produced in accordance with the method of claim 22.

24. A method for producing hybrid wheat seeds which comprises the following steps:

(a) treating seeds of *T. aestivum*, having homozygous specific nuclear genes interacting with its alien *Ae. squarrosa* cytoplasm to maintain fertility, to cause mutation of specific nuclear gene into mutated nuclear gene, said *Ae. squarrosa* cytoplasm requiring interaction with at least one specific nuclear gene to maintain fertility;

(b) selfing plants grown from the treated seeds and selecting those resultant seeds containing homozygous mutated nuclear genes;

(c) crossing male sterile plants from seeds of step "b" with T. aestivum plants to produce seeds;

(d) pollinating T. aestivum plants with pollen of plants grown from seeds produced in step "c",

(e) selfing plants grown from seeds produced in step "d";

(f) selecting seeds from step "e" having homozygous mutated nuclear genes;

(g) crossing plants grown from seeds selected in step "f" with plants grown from seeds selected in step "b" to multiply the seed having *Ae. squarrosa* cytoplasm and homozygous mutated nuclear genes in its *T. aestivum* nucleus;

(h) crossing plants having *Ae. squarrosa* cytoplasm and homozygous mutated nuclear genes in *T. aestivum* nucleus with euplasmic *T. aestivum* to produce hybrid wheat seeds.

25. A product produced in accordance with the method of claim 24.

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U.S. Patent No. 4,406,086

United States Patent [19]

Hayward

[11] **4,406,086**

[45] **Sep. 27, 1983**

[54] **WHEAT AND METHOD OF PRODUCING THE SAME**

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[52] U.S. Cl. 47/58; 47/DIG. 1

[58] Field of Search ..... 47/58, DIG. 1

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[57] **ABSTRACT**

The method of producing wheat seeds comprising the steps of crossing plants grown from a first cross of 'Thorne' and 'Clarkan'; and crossing the plants from the seeds of Thorne/Clarkan with plants from the seed of 'Etoile de Choisy'; crossing seeds from a semi-dwarf mutant of the Etoile de Choisy//Thorne/Clarkan cross with plants grown from the seeds of CI 13390; and crossing the offspring therefrom with plants grown from seeds of 'Coker 68-15'; and selfing plants grown from the seeds of this cross. Selfing of plants after each cross to permit a pure line selection is done. The product of this method further defines the invention.

2 Claims, No Drawings

65090

PLAINTIFF'S EXHIBIT F

WHEAT AND METHOD OF PRODUCING THE SAME

BACKGROUND OF THE INVENTION

This invention relates to wheat and the method of producing the same.

Many varieties of wheat have been developed to accommodate different growing conditions, wheat usages, and disease and insect resistance. Winter wheat grown in colder climates varies from spring wheat in more moderate climates; hard wheat and soft wheat have different nutritional characteristics, and some wheat varieties are better suited to resist certain insects and diseases than others.

Despite the advances which have been made in wheat breeding, the wheat industry is lacking a wheat which yields consistently high, and which at the same time has good to excellent qualities in the areas of milling and baking; disease and insect resistance; and good straw strength.

It is therefore an object of this invention to provide a soft red winter wheat which has a high yieldability, and which at the same time possesses good milling and baking qualities; good disease and insect resistance; and good straw strength.

These and other objects will be apparent to those skilled in the art.

SUMMARY OF THE INVENTION

The method of this invention entails the selective sequential crossing of certain predetermined known wheat varieties in conjunction with the making of pure line selections after the plants of each cross are selfed. The basic crosses of this invention are as follows:

(1) Thorne/Clarkan.

(2) Etoile de Choisy with Thorne/Clarkan.

(3) Etoile de Choisy//Thorne/Clarkan with CI 13390.

(4) Coker 68-15 with Thorne/Clarkan//Etoile de Choisy/3/CI 13390.

This creates the genealogy of:

Coker 68-15/4/Etoile de Choisy//Thorne/Clarkan/3/CI 13390.

Plants from the last cross are selfed to provide the pure line of wheat of this invention which is referred to herein as variety '2550', *Triticum aestivum* L., em Thell, which is a soft red winter wheat.

DETAILED DESCRIPTION OF THE INVENTION

The wheat varieties used in the method of this invention, resulting in the product of this invention, are known in the art and are identified herein by the designations by which they are identified in the art. Further details of the genealogy of these varieties are a matter of public record and are readily available.

The initial step of this invention is to cross the plants of Thorne and Clarkan. The plants from the seed of this cross were selfed to permit a pure line selection which reflected the characteristics of the cross as distinguished from the characteristics of either parent.

Plants from the pure line selection of the preceding cross were then crossed with plants from the French variety, Etoile de Choisy. The cross between Etoile de Choisy//Thorne/Clarkan has been made in the prior art and does not of itself constitute a part of this invention. Plants from this cross were selfed, and seed was selected from a semi-dwarf mutant. Plants from the seed of this mutant were then crossed with plants from the seed of CI 13390. Through selfing, a pure line selection from this cross was crossed to Coker 68-15.

Selections were made from the F_2 generation of the last-described cross for plant height, straw strength, maturity and head type. The F_3 generation was then made from these selections, and further selections were then made for winterhardiness, height, maturity, straw strength, disease resistance and for plant and head type. Seed from this selection was used for the F_4 generation which was examined particularly for yieldability. A reselection was made from an F_5 generation and traced to a single F_4 plant. Plants from this selection were tested in yield trials and for milling and baking quality. Final selection was made in the F_8 generation and this selection is variety 2550, *Triticum aestivum* L., em Thell.

2550 has shown uniformity and stability for all of the traits described in Table I, with the only variant observed and expected is a very low frequency of awns (<1/30,000).

TABLE I

OBJECTIVE DESCRIPTION OF VARIETY

Kind: Common
Type: Winter, soft, red
Season - Number of days from emergence to:
- (a) First flowering: 229
- (b) Last flowering: 236

Maturity (50%): Flowering: 2 days later than 'Arthur'
Plant Height: 95 cm high (4 cm shorter than Arthur)
Plant Coloring at Booting: Blue green
Stem:
- (a) Anthocyanin: Absent
- (b) Hairiness of last internode of rachis: Absent
- (c) Number of nodes: 4
- (d) Waxy bloom: Present
- (e) Internodes: Hollow
- (f) Cm internode length between flag leaf and leaf below: 22

Auricles:
- (a) Anthocyanin: Absent
- (b) Hairiness: Absent

Leaf:
- (a) Flag leaf at booting stage: Recurved
- (b) Hairs of first leaf sheath: Absent
- (c) Width of first leaf below flag leaf: 12 mm
- (d) Flag leaf: Not twisted
- (e) Waxy bloom of flag leaf sheath: Present
- (f) Length of first leaf below flag leaf: 23 cm

Head:
- (a) Density: Lax
- (b) Awnedness: Awnleted
- (c) Color at maturity: Yellow
- (d) Length: 8 cm
- (e) Shape: Tapering
- (f) Width: 12 mm

Glumes at Maturity:
- (a) Length: Long (CA. 9 mm)
- (b) Shoulder shape: Oblique
- (c) Width: Wide (CA 4 mm)
- (d) Beak: Acute

Coleoptile Color: White
Juvenile Plant Growth Habit: Semi-erect
Seed:
- (a) Shape: Ovate
- (b) Brush: Medium
- (c) Phenol reaction: Very dark brown, nearly black, similar to 'Monon'
- (d) Color: Red
- (e) Length: 7 mm
- (f) Width: 3 mm
- (g) Cheek: Rounded
- (h) Brush: Not collared
- (i) Weight per 1000 seeds: 36 gm

Seed Crease:
- (a) Width: 60% or less of kernel 'Winoka'
- (b) Depth: 20% or less of kernel 'Scout'

Disease:
- (a) Stem rust: Susceptible
- (b) Loose smut: Susceptible
- (c) Soil Borne Mosaic Virus: Resistant
- (d) Spindle Streak Mosaic Virus: Resistant

Insect:
- (a) Aphid: Resistant
- (b) Hessian fly: Susceptible to races B, D, E and G; resistant to races GP, A, C and F

Resemblance to Known Varieties:

Character	Name of Variety
Plant tillering	'Abe'
Leaf size	Abe
Leaf color	'McNair 1003'
Leaf carriage	Abe
Seed size	'Pioneer Variety 576'
Seed shape	Pioneer Variety 576
Coleoptile elongation	Pioneer Variety 576
Seedling pigmentation	Pioneer Variety 576

Deposit of 2550 seeds has been made prior to the filing of this application at the National Seed Storage Laboratory, Colorado State University, Fort Collins, Colo., under Laboratory Accession No. TV 24904 and NSSL Serial Number 163525.

As reflected in the above Table I, the flowering date of 2550 is two days later than the variety Arthur and one day earlier than Pioneer variety S76. At Tipton, Ind., when seeded about October 1, average first flowering is May 27 or about 229 days after emergence. Last flowering averages about seven days later. Environmental factors influence flowering of varieties differently.

2550 has averaged 95 cm in height, which is about 4 cm shorter than Arthur and Pioneer variety S76.

The plant color of 2550 at booting stage is a distinct blue-green while Arthur is green and 'Beau' is dark green. Another color of 2550 is yellow, similar to Pioneer variety S76.

Anthocyanin has been absent in the stem of 2550. A heavy waxy bloom occurs on the stem. Internodes of 2550 are hollow. At maturity, the stems are yellow and strong. Normally four stem nodes are present above ground. Internode length between flag leaf and leaf below is about 22 cm. The last internode of the rachis is free of hairiness.

Auricles of 2550 are lacking in anthocyanin and are free of hairiness.

Flag leaves are generally recurved at booting and are not twisted. Hairs are absent from the first leaf sheath. A heavy waxy bloom occurs on the flag leaf sheath. The first leaf below the flag leaf averages about 12 mm wide and 23 cm long.

Spikes are generally mid-dense to lax, tapering, awnleted, yellow and generally nodding at maturity. The apical awnlets are rough and about 15–20 mm long. Spike width and length averages about 12 mm and 8 cm, respectively. However, spike width and length are variable with plant population and level of production.

The glumes of 2550 are long and wide, glabrous and generally the shoulders are oblique. The beaks are acute.

The coleoptile color is white and seedling anthocyanin is absent. Juvenile plant growth habit is semi-erect.

The kernels are red in color, ovate in shape, with rounded cheeks and a shallow crease. The brush is not collared and medium in size. The embryo is large in size. The kernels average 7 mm long and 3 mm wide and weight about 36 g per 1000. Phenol reaction is very dark brown, nearly black, similar to Monon.

2550 is moderately resistant to leaf rust (*Puccinia recondita* f. sp. *tritici*) and susceptible to stem rust (*P. graminis* f. sp. *tritici*) races currently common in the soft red winter wheat region. 2550 has not been tested for specific races of leaf rust nor has it been tested for stripe rust (*P. striiformis*), bunt (*Tilletia foetida* and *T. caries*) and loose smut (*Ustilago tritici*). While susceptible to powdery mildew (*Erysiphe graminis* f. sp. *tritici*), the progression of the disease up the plant is slow.

2550 has a good level of resistance to soil borne mosaic virus, spindle streak mosiac virus and barley yellow dwarf virus. In testing for BYDV, 'Clintland 64' oat variety was used as a very susceptible check, Abe as the susceptible wheat variety check and 'Hart' as a wheat variety check with notable resistance. Results were as follows: Clintland 64-6; Abe-5; Hart-3; 2550-2.

2550 is resistant to Hessian fly races GP, A, C and F and susceptible to races B, D, E and G. 2550 has not been tested for sawfly, greenbug and cereal leaf beetle.

2550 is most similar to the soft red winter Pioneer variety S76 in a number of plant and seed characteristics. Certain similarities are expected since one half the parentage of 2550 and S76 is the same. However, there are a number of distinguishable differences between the two varieties. The most easily recognized difference is that S76 is awned and 2550 is awnleted. Plant height of 2550 averages about 4 cm shorter. Less notable differences between the two varieties are: The plant color of 2550 at booting stage is a distinct blue-green, while S76 is green to slight blue-green. A heavy waxy bloom occurs on the stem and flag leaf sheath of 2550 while only a light and moderate waxy bloom occurs on the stem and flag leaf sheath respectively of S76. Shoulders of the glume are oblique on 2550 and wanting on S76. Beaks are acute on 2550 and acuminate on S76.

As reflected in Table 2, 2550 is higher yielding and has a higher level of field resistance to prevalent races of leaf rust and powdery mildew than S76. S76 has better straw strength and more resistance to spindle streak mosaic virus and soil borne mosaic virus than 2550.

TABLE 2

Performance of Pioneer Varieties 2550 and 2553 and Standard Varieties Grown in Elite Yield Trials

Variety	Yield bu/acre (72)***	Test Weight lbs/bu (51)	Height cm (48)	Days to Flowering after 4/1 (39)	Lodging** Score (45)	Powdery** Mildew (13)	Leaf** Rust (9)	Spindle Streak** Mosaic Virus (3)	Soil Borne** Mosaic Virus (4)
2550	71.4	57.6	95	55.4	6.5	6.1	8.0	7.0	6.2
2553	68.0	59.0	96	55.7	8.2	3.8	6.8	8.0	7.0
S76	63.4	57.8	99	56.4	7.5	4.1	6.4	8.3	7.5
S78	62.6	57.5	93	57.2	6.8	3.5	7.3	8.7	5.8
Hart	62.4	57.8	103	55.1	6.7	4.1	5.7	7.7	7.0
Abe	60.2	58.7	99	54.3	4.7	6.2	4.5	4.7	4.2

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TABLE 2-continued

Performance of Pioneer Varieties 2550 and 2553 and Standard Varieties Grown in Elite Yield Trials

Variety	Yield bu/acre (72)***	Test Weight lbs/bu (51)	Height cm (48)	Days to Flowering after 4/1 (39)	Lodging** Score (45)	Powdery** Mildew (13)	Leaf** Rust (9)	Spindle Streak** Mosaic Virus (3)	Soil Borne** Mosaic Virus (4)
Beau	39.9	59.4	99	54.8	6.2	6.6	4.9	5.0	4.0
Sullivan	38.1	59.2	103	53.6	4.5	6.2	3.5	4.0	5.8

**Scale 1-9 where 9 = excellent or resistant and 1 = poor or 100% susceptible
***Number in parenthesis - replications.

Since half the parentage of 2550 is Coker 68-15, there are similarities between 2550 and Coker 68-15. These varieties are readily distinguishable by their level of winterhardiness. In winterhardiness tests (1-9 scale with 9 being most winterhardy), the average readings were 7.0 and 3.0 for 2550 and Coker 68-15 respectively.

As shown in Table 2, 2550 has an excellent yield record when compared with the current leading soft red winter wheat varieties, including approximately a 10% increase in yield over Pioneer variety S76. In the presence of soil borne mosaic virus or spindle streak mosaic virus, 2550 has a pronounced yield advantage over susceptible varieties. Short plant height and good straw strength give 2550 excellent resistance to lodging, and this enhances yieldability.

The milling and baking qualities of 2550 are generally equivalent to current varieties commonly grown in the SRW region. Flour protein is consistently lower (desirable) than Abe. It has better protein levels and break flour yields than Pioneer variety S76, as shown in the following Table 3.

TABLE 3

Results of Quality Testing on 2550 (Pioneer Wheat Quality Lab)

Test/Sample	Flour Yield (%)	Break Flour (%)	Flour Protein (%)	AWRC (%)	Cookie Diam. (cm.)	PSI (%)
Test I - Average Data (2 locations)						
2550	67.6	36.4	10.7	55.3	17.9	45.6
Abe	66.7	37.3	12.5	53.3	17.9	51.9
Avg. all checks	67.4	37.0	12.3	53.7	17.8	52.2
Test II - Average Data (3 locations)						
2550	66.0	33.9	7.5	54.3	19.7	44.8
Abe	68.2	35.4	8.3	51.4	19.2	51.1
Avg. all checks	65.6	35.3	8.7	53.9	19.3	48.8
Test III - Average Data (6 locations)						
2550	66.1	34.8	7.6	56.2	19.3	43.7
Abe	67.2	34.1	8.5	53.8	19.5	46.3
Avg. all checks	66.3	33.8	8.7	54.2	19.5	44.8
Test IV - Average Data (7 locations)						
2550	70.0	38.1	9.4	55.4	18.8	32.7
Abe	70.2	36.1	10.4	53.7	18.7	32.2
Avg. all checks	69.1	36.2	10.4	54.4	18.6	31.7

NOTES:
Locations tested include: Longmont, Illinois; Fort Branch and Tipton, Indiana; and Tiffin, Ohio.
Check varieties include various combinations of: Abe, Beau, Coker 68-15, Double Crop, Pioneer W304, Hart, McNair 3001, Omni, Roland, Ruler, Sullivan and Titan.
Methods:
Milling = Brabender Quadrumat Sr. Mill
Protein - Udy method
AWRC - Micro method on milled flour
Cookie diameter - mean diameter of two cookies
PSI - Through '79 - Sonic sifter
- From '80 on - A B grader, sieve shaker

While making the crosses of the method of this invention, the variety used as the male or female is not deemed to be crucial, although the first designated variety is deemed to be the female parent, and the second variety is the male parent. The crosses are accomplished by conventional methods whereby male anthers are removed from a plant to create a female plant; the head of the female plant is then covered to protect contamination; and then pollen grain from anthers of the desired male plant are deposited on the stigmas of the female plant which remains covered to prevent contamination.

The principal advantage of 2550 is its high yieldability which demonstrates a substantial improvement over existing varieties. This high yieldabilty, coupled with good milling and baking qualities, good disease and insect resistance, and good straw strength, provides a superior wheat. Accordingly, this invention is seen to accomplish at least all of its stated objectives.

What is claimed is:

1. A method of producing wheat seeds, comprising:
(a) crossing plants grown from seeds of Thorne and Clarkan;
(b) developing a pure line from the seeds produced in step "a", and crossing plants from such line with plants grown from seeds of Etoile de Choisy;
(c) developing a pure line from the seeds from a semidwarf mutant produced in step "b", and crossing plants from such line with plants grown from seeds of CI 13390;
(d) developing a pure line from the seeds produced in step "c" and crossing plants from such line with plants grown from seeds of Coker 68-15;
(e) and developing a pure line from the seeds produced in step "d" and harvesting the seed resulting from said line.

2. Seed produced in accordance with the method of claim 1.

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